CHAPTER 12: MANUFACTURER IMPACT ANALYSIS

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CHAPTER 12: MANUFACTURER IMPACT ANALYSIS

12.1 MANUFACTURER IMPACT ANALYSIS METHODOLOGY

In determining whether a standard is economically justified, the Secretary of Energy is required to consider "the economic impact of the standard on the manufacturers and on the consumers of the products subject to such a standard."[a] The legislation also calls for an assessment of the impact of any lessening of competition as determined in writing by the Attorney General. The Department conducted the manufacturer impact analysis (MIA) to estimate the financial impact of efficiency standards on manufacturers of distribution transformers and to assess the impact of such standards on employment and manufacturing capacity. The MIA has both quantitative and qualitative components. The quantitative part of the MIA primarily relies on the Government Regulatory Impact Model (GRIM), an industry-cash-flow model adapted for this rulemaking. The key GRIM inputs relate to industry cost structure, shipments, and pricing strategies. The GRIM's key output is the industry net present value (INPV). The model estimates the financial impact of higher efficiency standards by comparing changes in INPV between the base case and the various trial standard levels. The qualitative part of the MIA addresses factors such as the material supply chain, manufacturing techniques and equipment, market and product trends, and includes a subgroup assessment of the impacts on small manufacturers.

In the Department's Framework Document published on November 1, 2000, DOE outlined the procedural and analytical approaches for the MIA. As outlined, the Department conducted the MIA in three phases. Phase 1, "Industry Profile," consisted of the preparation of an industry characterization, including data on market share, sales volumes and trends, pricing, employment and financial structure. Phase 2, "Industry Cash Flow," focused on the industry as a whole. In this phase, DOE used the GRIM to prepare an industry cash flow analysis. Using publicly available information developed in Phase 1, the Department adapted the GRIM's generic structure to perform an analysis of distribution transformer energy conservation standards. In Phase 3, the "Sub-Group Impact Analysis," DOE conducted interviews with several manufacturers. The group of manufacturers included small, medium, and large manufacturers providing a representative cross-section of the U.S. distribution transformer industry. During these interviews, the Department discussed engineering, manufacturing, procurement, and financial topics specific to each company and also obtained each manufacturer's view of the industry as a whole under standards. The interviews provided valuable information that the Department used to evaluate the impacts of a standard on manufacturers' cash flows, manufacturing capacities, and employment levels.

This chapter provides detail on the approach followed by the Department in developing the MIA for this rulemaking.

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[a] The Department of Energy's standards program for commercial equipment is conducted under Title III, Part C of the Energy Policy and Conservation Act (EPCA), 42 U.S.C. 6311-6317.

12.1.1 Phase 1: Industry Profile

In Phase 1 of the MIA, the Department prepared a profile of the distribution transformer industry that built upon the market and technology assessments prepared for the Advance Notice of Proposed Rulemaking (ANOPR) analysis. Prior to initiating the detailed impact studies, DOE collected information about the present and past industry structure and market characteristics for distribution transformers. At that time, DOE collected information on national shipments, market leaders, and cost structure for a range of manufacturers. In creating the industry profile, the Department gathered information about product construction, product characteristics, manufacturing techniques, trends in the number of firms, and market characteristics.

The industry profile included a topdown cost analysis of the distribution transformer industry that DOE used to derive initial cost and financial inputs for the GRIM, e.g., revenues; material; labor; overhead; depreciation; selling, general and administrative expenses (SG&A); and research and development (R&D) expenses. The Department used public sources of information to calibrate its initial characterization of the industry, including Securities and Exchange Commission (SEC) 10–K reports, corporate annual reports, the U.S. Census Bureau's Economic Census, Dun & Bradstreet reports, and industry analysis from Ibbotson Associates.

12.1.2 Phase 2: Industry Cash Flow Analysis

Phase 2 of the MIA focused on the industry-wide financial impacts of standards. Energy conservation standards can affect distribution transformer manufacturers in three distinct ways: 1) require additional investment, 2) raise production costs, and 3) impact revenues through higher prices and, possibly, lower shipments. The analytical tool DOE uses for calculating the financial impacts of standards on manufacturers is the GRIM. To quantify these impacts in Phase 2 of the MIA, the Department performed a distribution transformer industry cash flow analysis using the GRIM.

For the industry cash flow analysis, DOE prepared a set of financial parameters for use in the GRIM. These financial parameters were originally based on the Department's topdown financial analysis, but based upon discussions with transformer manufacturers, were subsequently adjusted to be more representative of the industry. The Department used a similar process during the Advanced Notice of Proposed Rulemaking Phase (ANOPR) of the analysis (i.e., public financial reports and manufacturer discussions) to derive the manufacturer markups used to establish manufacturer selling prices in the Department's engineering analysis. The MIA production costs and manufacturer selling prices are consistent with both the LCC analysis and the engineering analysis, upon which the LCC pricing is based. The Department established this consistency by using the mean values for production costs and selling prices in the GRIM, as selected by the LCC's Monte Carlo algorithm. Finally, the Department's shipments analysis (Chapter 9) provided the basis for the shipments projection under each of the TSLs in the GRIM.

12.1.3 Phase 3: Sub-Group Impact Analysis

Using average cost and financial assumptions to develop an industry cash flow model is not adequate for assessing differential impacts among subgroups of manufacturers. Smaller manufacturers, niche players, or manufacturers exhibiting a cost structure that differs largely from the industry average could be more negatively impacted. The Department used the results of the industry characterization to group manufacturers exhibiting similar characteristics. As discussed in the ANOPR, the Department established three distinct subgroups of distribution transformer manufacturers that could be impacted by efficiency standards: liquid-immersed, low-voltage (LV) dry-type, and medium-voltage (MV) dry-type. A discussion of the superclasses follows in section 12.1.3.1.

Within each of these superclasses, the Department contacted companies from its database of manufacturers (see Chapter 3) which provided a representation of each superclass. Small and large companies, subsidiaries and independent firms, public and private corporations, and a mix of NEMA and non-NEMA members were interviewed. The Department also made an effort to interview companies who had been interviewed for the Engineering Analysis in 2002, as well as those who have previously participated in the rulemaking process. The purpose of the meetings was to enhance the Department's understanding as to how manufacturer impacts change with each of the trial standard levels. A copy of the interview guides for each of three superclasses can be found in Appendix 12.A.

The Department also evaluated the impact of the energy conservation standards on small businesses. Small businesses, as defined by the Small Business Administration (SBA) for the distribution transformer manufacturing industry, are manufacturing enterprises with 750 or fewer employees. The Department conducted telephone interviews with nine small businesses, to determine if there are differential impacts on these companies that may result from the standard. A copy of the interview guide for these interviews can be found in Appendix 12.B. Discussion on the purpose of the small business interviews and the small-business subgroup methodology follows in section 12.1.3.2.

The Department contacted material and equipment suppliers to the distribution transformer industry to enhance its understanding of the context in which transformer manufacturers operate and to assist in quantifying conversion costs. The Department conducted interviews with the two domestic suppliers of electrical core steel and with two core steel distributors. The domestic suppliers of core steel are large corporations which have a broad range of steel products of which electrical core steel is one product offering. The core steel distributors offer manufacturers a varying degree of processing, ranging from basic slit-to-width rolls to prefabricated cores (both stacked and wound-core configurations). The Department also spoke with four equipment suppliers, including manufacturers of both distributed gap and mitered core processing machines, and two manufacturers of annealing furnaces. The information from these discussions was helpful in understanding comments and concerns expressed by manufacturers as well as in estimating the conversion capital expenditures used in the GRIM. To prepare the liquid-immersed industry conversion costs for switching to amorphous material at TSLs 5 and 6, the Department spoke with the only domestic supplier of amorphous ribbon and several transformer manufacturers who had experience working with amorphous material. Through this dialogue, the Department gained a better understanding of manufacturing amorphous core transformers, including core processing equipment, annealing furnaces, and material handling issues.

12.1.3.1 Major Manufacturer Subgroups - Superclasses

As proposed at the ANOPR public workshop, the Department subdivided the distribution transformer industry into three 'superclasses': liquid-immersed, LV dry-type and MV dry-type. These superclasses take into account differences among the manufacturers, including the equipment and tooling used, product designs, customer types, and the characteristics of the markets in which the manufacturers operate. The Department believes that modeling the industry in three separate subgroups offers a robust analytical approach for three reasons:

1. Customer profiles and market mechanisms - generally, the profile of the majority of customers purchasing transformers and the manner in which they are built and sold within each of the three superclasses is distinct. Discussion on customer profiles and distribution chains can be found in the LCC analysis (Chapter 8).

2. Manufacturing equipment and transformer design - within each of the three superclasses, the equipment necessary for production and the methods by which manufacturers build transformers are grouped. For example, in the liquid-immersed superclass, transformer cores tend to be wound, requiring distributed-gap core winding machines, annealing furnaces, tanking machines, and other equipment that is only used in this superclass. Accordingly, the capital equipment investment necessary for compliance with a particular trial standard level typically differs among the three superclasses.

3. Industry structure - reviewing the database of transformer manufacturers, the Department observed that many companies operate and specialize in one of the distribution transformer superclasses. For large companies that operate in more than one superclass, each manufacturing facility tends to be dedicated to producing transformers from one of the superclasses. Thus, the industry naturally breaks down into these three superclasses. The primary exception to this general statement is that a single manufacturing facility can produce both LV dry-type and MV dry-type distribution transformers because of the commonalities in these superclasses' products.

12.1.3.2 Small-Business Subgroup

The Department undertook a small business subgroup analysis in order to assess the importance of small businesses within the distribution transformer industry and to understand how the impacts of standards on small business might be different from those on large manufacturers. Small businesses, as defined by the Small Business Administration (SBA) for the distribution transformer manufacturing industry, are manufacturing enterprises with 750 employees or fewer.[b] To prepare a list of eligible companies, the Department constructed a transformer manufacturers database containing available data from eleven sources including the Department's stakeholder contact list for this rulemaking, the Oak Ridge National Laboratory determination analysis database, the Underwriters Laboratory (UL) certification database, the National Electrical Manufacturers Association membership list (NEMA), and the Transformer Association membership list. (Details about the compilation of this database and the sources used are discussed in the market and technology assessment, Chapter 3.) Small businesses were then selected and contacted to assess their interest in participating in an interview. If they were

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[b] Small Business Administration - www.sba.gov/size/indextableofsize.html

agreeable, the Department sent a short questionnaire to the small businesses and a date was scheduled for discussion. A copy of the small business interview guide can be found in Appendix 12.B.

The Department's database of transformer manufacturers includes approximately 45 small businesses, most of which have less than 100 employees. Small businesses operate in all three superclasses. The database identifies 15 small businesses that sell liquid-immersed distribution transformers, 30 that sell LV dry-type, and 20 that sell MV dry-type. The total of these three groups exceeds 45 because several of these small businesses operate in more than one superclass (e.g., LV dry-type and MV dry-type transformers are often produced by the same small business). Upon reviewing the material provided by the small businesses interviewed, the Department concluded that using the GRIM was not the best way to capture and represent the differential impacts on small business. Instead, the differential impacts on small business are discussed qualitatively for each of the three superclasses in this chapter.

12.2 MANUFACTURER KEY ISSUES

The first question of each of the MIA interview guides asks, "What are the key issues for your company regarding the distribution transformer energy conservation standard rulemaking?" This open question initiated the dialogue with the manufacturers, enabling them to identify key points that the Department would explore and discuss during the interview. This section lists those issues that were raised most often by the manufacturers interviewed.

Manufacturers indicated that, for the most part, the risks associated with these issues increase with increasing TSL. Discussion and consideration of many of these issues are discussed later in this chapter.

- Core steel availability - concern was expressed over whether sufficient quantities of high grade core steels needed for the construction of energy efficient distribution transformers would be available. This concern is amplified by recent core steel availability problems in the U.S. market. Not only will the standard drive the market to higher grades of steel (which are thinner, and therefore take more time for steel companies to manufacture) but the quantities (pounds of steel) per transformer will also increase. Transformer manufacturers are concerned that these compounding factors may further limit the availability of core steel.

- Core steel price volatility and uncertainty - starting in late 2003, core steel prices started to increase. Core steel prices increased dramatically after mid-2004. For some manufacturers core steel prices have doubled since 2003. In response to these and other material input cost increases, transformer manufacturers have been raising their own prices. However, transformer manufacturers report that they have not passed through all input cost increases to customers. Furthermore, manufacturers questioned the cost-effectiveness of energy conservation standards under higher steel prices. They commented that higher transformer selling prices (driven by the higher material inputs prices), would erode customer cost savings and lengthen the payback periods of transformers under standards. Core steel price uncertainty is addressed in the Department's core steel price scenarios as part of the engineering analysis (see Chapter 5 of this Technical Support Document).

- Dimensional and physical constraints - manufacturers expressed concern over meeting the Department's efficiency standard and their customers' dimensional and physical constraints simultaneously. In particular, manufacturers voiced concern for retrofit applications, mining applications, telephone pole capacities, and other installations where transformers have to comply with dimensional or physical constraints.

- Enforcement of efficiency standard - manufacturers expressed concern over how the Department intended to enforce the standards, to make sure that all manufacturers, particularly importers, comply with the regulations.

- Definition loopholes - manufacturers cautioned that if the standard is set above a certain level, some customers may start looking for standards relief by specifying transformers from the Department's exemption list and using them in general purpose applications.

- Amorphous material - liquid-immersed manufacturers expressed their concern that the Department is considering amorphous material at some of its TSLs. In particular, they discussed concerns about: 1) the ease of access to the technology, 2) the availability of amorphous-core material at quantities necessary to meet industry demand, 3) the level of capital equipment investment, 4) increased complexity associated with material processing and handling during manufacturing, and 5) the consequent obsolescence of existing core fabrication and annealing capacity within the industry.

- Backsliding - liquid-immersed manufacturers identified two impacts related to backsliding. Manufacturers report that they are currently beginning to experience these impacts as a result of state standards (one state has enacted NEMA TP-1 for liquid-immersed transformers). Manufacturers have reported that, in the state that has enacted TP-1, some utility customers have ceased evaluating their purchases and are simply purchasing standards-compliant transformers. According to manufacturers, while the minimum efficiency of transformers sold in this state has increased, the average efficiency has decreased. The first impact of such backsliding is that liquid-immersed manufacturers may experience lower revenue. Secondly, the liquid-immersed market may move from a highly customized market, where U.S. manufacturers enjoy a competitive advantage over foreign manufacturers because of their flexibility and short lead times, to a homogenized, commoditized market. Ultimately, liquid-immersed manufacturers suggest that this may lead to a deterioration in the U.S. manufacturing base of liquid-immersed distribution transformers.

12.3 GRIM INPUTS AND ASSUMPTIONS

12.3.1 Overview of GRIM

The GRIM serves as the main tool for assessing the impact on industry due to the implementation of efficiency standards. The GRIM is a financial model of the industry that captures the impact of efficiency standards on industry value. The basic structure of the GRIM, illustrated in Figure 12.3.1, is a standard annual cash flow analysis that uses manufacturer prices, manufacturing costs, shipments, and industry financial information as inputs, and accepts a set of regulatory conditions as changes in costs, investments, and associated margins. The GRIM spreadsheet calculates a series of annual cash flows, beginning with the base year of the analysis, 2004, and continuing explicitly to 2038. The model calculates the INPV by summing the stream of annual discounted cash flows during this period.[1]

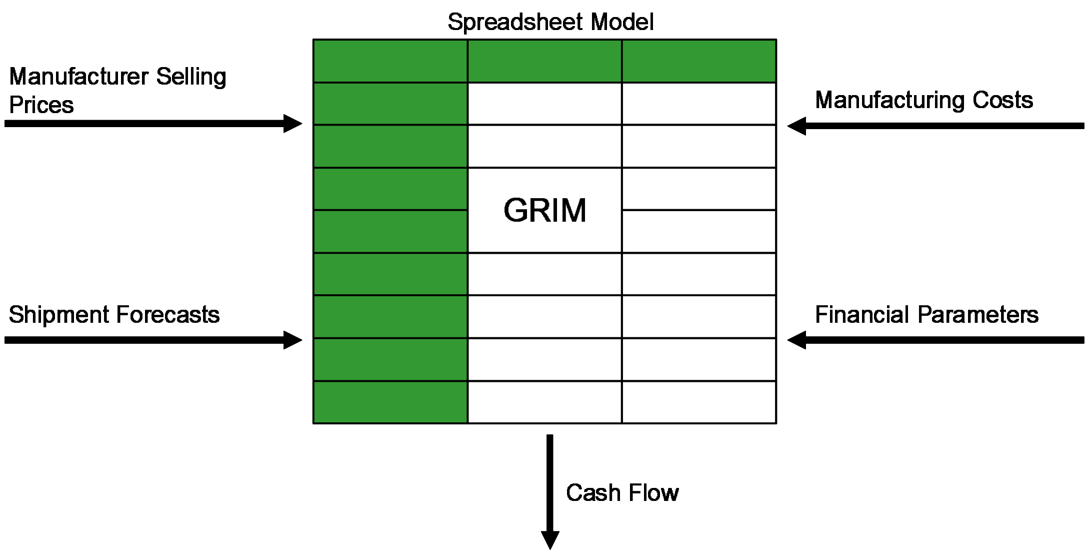

Figure 12.3.1 Using the GRIM to Calculate Cash Flow

The Department used the GRIM to project cash flows based upon standard accounting principles and compared changes in INPV between a base case (no mandatory standard) and different TSLs for the energy conservation standard (the standard case). The difference in INPV between the base case and the standard case(s) represents the financial impact of the standard on manufacturers. Appendix 12.C provides more technical detail and user information for the GRIM.

12.3.2 Financial Parameters

The Department relied on several sources to obtain financial inputs and assumptions for the GRIM, including corporate annual reports and the manufacturer interviews. Corporate annual reports to the Securities and Exchange Commission (SEC 10-Ks) provided many of the draft financial inputs to the GRIM.[2] These reports exist for publicly held companies, and are freely available to the general public. The Department used these annual reports to derive the following draft GRIM inputs:

- Tax rate,

- Working capital,
- Selling, general, and administrative expenses,
- Research and development expenses,
- Depreciation,
- Capital expenditures, and
- Net property, plant, and equipment (i.e., net of accumulated depreciation).

The Department then revised its own estimates of financial parameters through interviews with manufacturers during both the ANOPR and NOPR phases of the rulemaking. The Department relied on manufacturer input for these revisions for two reasons. First, many distribution transformer manufacturers, both large and small, are not public corporations so industry-wide financial data are not readily available. Second, many manufacturers of distribution transformers are diverse businesses that participate in markets that are substantially different from distribution transformer markets; therefore, the available financial information is not clearly representative of the distribution transformer market. Table 12.3.1 provides the representative financial parameters that were used for all three superclasses in the distribution transformer GRIM.

The Department also used information from the SEC 10-K reports to calibrate the GRIM's base case operating profit margin to be representative for the industry. Operating margin is defined as earnings before interest and taxes as a percentage of net revenue. The Department calibrated the GRIM to have a 4.9 percent operating margin in the base case.

Table 12.3.1 GRIM Financial Parameters for Distribution Transformer Industry

Parameter	Representative Value for Liquid-Immersed	Representative Value for LV Dry-Type	Representative Value for MV Dry-Type
Tax Rate (% of Taxable Income)	30.0%	35.9%	33.9%
Net Working Capital (% of Revenues)	15.4%	14.9%	10.6%
SG&A (% of Revenues)	13.5%	13.5%	14.0%
R&D (% of Revenues)	1.6%	2.3%	1.1%
Depreciation (% of Revenues)	1.6%	1.6%	1.8%
Capital Expenditures (% of Revenues)	1.9%	1.9%	2.1%
Net Property, Plant, and Equipment (% of Revenues)	16.6%	20.0%	16.1%

Source: SEC, 10-K Reports, Fiscal Years 1999-2004. Revised based on discussion with manufacturers.

12.3.3 Corporate Discount Rate

The Department uses the weighted-average cost of capital (WACC) for the industry as the discount rate to calculate INPV. A company's assets are financed by a combination of debt and equity. The WACC is the total cost of debt and equity weighted by their respective proportions in the capital structure of the industry.[1] The Department estimated the WACC for the industry based on a few representative companies using the following formula:

WACC = After-Tax Cost of Debt x (Debt ratio) + Cost of Equity x (Equity Ratio)

The cost of equity is the rate of return that equity investors expect to earn on a company's stock. These expectations are reflected in the market price of the company's stock. The capital asset pricing model (CAPM) provides one widely used means to estimate the cost of equity. According to the CAPM, the cost of equity (expected return) is:

*Cost of equity = risk free rate of return + Beta * risk premium*

where:

Risk free rate of return is the rate of return on a "safe" benchmark investment. In practice, investors use a variety of different maturity Treasury notes to estimate the risk-free rate. The Department used a long-term Treasury note return (10-year bond return) because it captures long-term inflation expectations and is less volatile than short-term rates in the GRIM. The risk free rate was estimated to be 6.2 percent, which is the average 10-year Treasury note return from 1990 to 2003.

Risk premium is the difference between the expected return on stocks and the riskless rate, assumed to be 9.2 percent.

Beta is the covariance of a stock with the market as a fraction of the market's variance. The Beta equals one if the stock is perfectly correlated with the S&P 500 market index. A Beta lower than one means the stock is less volatile than the market index. For this analysis, Beta was assumed to be equal to 0.8.

Using these inputs, the Department estimated the cost of equity (expected return) to be 13.6 percent.

The Department estimated the cost of debt for each company based on the average interest rate reported on each company's SEC 10-K report. The average cost of debt was estimated to be 6.6 percent. Assuming a marginal tax rate of 35 percent, the after-tax cost of debt is 4.3 percent. The Department estimated the debt ratio (debt/total capital) of the industry to be 26 percent.[c] The equity ratio estimate is therefore 74 percent.

Using the formula for the WACC, the Department estimated the industry's WACC to be 11.2 percent. Subtracting an estimated inflation rate of 2.3 percent (assumed in the LCC analysis), the inflation adjusted WACC is 8.9 percent.

For validation, Ibbotson Associates[3] provided a WACC for a set of companies in the electric transmission and distribution equipment industry, which the Department assumed to be a good surrogate for the distribution transformer industry. The Ibbotson nominal WACC is 12.5 percent, which corresponds to an inflation-adjusted WACC of 10.3 percent. This is close to the Department calculated value of 8.9 percent.

During the manufacturer interviews, no manufacturer expressed disagreement with the industry-wide, inflation-adjusted WACC estimate of 8.9 percent (though some individual companies have substantially different costs of capital).

For the reasons discussed above, the GRIM uses an 8.9 percent discount rate for calculating the INPV of the distribution transformer industry.

12.3.4 Shipments

The GRIM used shipment projections derived from the Department's shipments model in the national impact analysis. The shipments model provides an estimate of the annual sales and in-service stock of distribution transformers for each year of the forecast period. The estimate includes both the age distribution of transformers for each type (according to product class) and

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[c] In previous rulemakings, this was based on book value; in this rulemaking a slightly more accurate debt ratio is based on market value of equity rather than book value; the book value of long-term debt, however, is used to estimate the debt ratio.

each transformer size. The Department selected an accounting model method to prepare shipment scenarios for the base case and the six trial standard levels. Chapter 9 of this Technical Support Document provides a description of the methodology and analytical model DOE used to forecast distribution transformer shipments.

In its shipments analysis, the Department determined that the demand for distribution transformers is relatively inelastic. Therefore, in the long-run, more expensive standards-compliant transformers are not expected to trigger substantial reductions in shipments. Transformers are understood to be a 'must-have,' thus the shipments analysis was modeled with a small price-elasticity. During the MIA interviews, several manufacturers expressed concerns over shipments, which they feel are subject to a greater price elasticity of demand than the Department estimates.

The Department was informed of three mechanisms by which higher standards could reduce shipments. Firstly, manufacturers commented that transformer budgets are often finite line items in a utility's overall budget, and as costs per unit increase, it is unlikely that utilities' transformer budgets will increase proportionately. Thus, proactive maintenance programs that replace and/or upgrade transformers nearing the end of their useful life will be reduced (on a unit basis), resulting in more failures and outages, and lower system reliability. The installed capital of the distribution network will be worked harder, and transformers will only be fixed upon failure. Secondly, utilities may increase their purchase of multi-voltage (primary) distribution transformers, enabling them to reduce inventories. Multi-voltage primary transformers are able to operate at more than one primary voltage, reducing the number of transformers kept in stock for emergencies and upgrades. Thirdly, engineers who specify transformer orders may look at an application, and select a slightly lower kVA rating than they ordinarily would have because of the higher (standards-compliant) price. For example, a customer who would have purchased a 50 kVA unit for an application may select a 37.5 kVA because of the cost increase for a standards-compliant 50 kVA. By working a lower kVA unit with a higher average load, its operating life will be reduced (compared to the larger kVA operating the same load), however on a first-cost basis, the specifier will have saved money. This risk of derating transformers ordered was not modeled in the shipment analysis. Furthermore, if lower kVA ratings are specified, the actual per unit loading may move away from the assumed 50% for liquid-immersed and MV dry-type and 35% for LV dry-type, resulting in greater load losses and lower system efficiency than modeled in the Department's national impact analysis.

Finally, the Department's shipments analysis does not take into account any constraints on the availability of materials for manufacturing transformers. Manufacturers expressed concern during the interviews about the availability of core steel. The transformer materials supply-chain has been experiencing consolidation over the years, such that now, manufacturers would be vulnerable to price changes or availability of wire, copper-sheet, electrical paper, mineral oil and other critical materials for building a transformer. Such input price changes would flow through to impact transformer prices. Since the Department's engineering analysis assumes flat equipment prices in real terms over time, the Department's shipments analysis cannot capture such second order impacts for any given set of equipment prices.

12.3.5 Production Costs

During the engineering analysis, the Department used transformer design software to create a database of designs spanning a broad range of efficiencies for each of the representative units. This design software generated a bill of materials, with information including pounds of core steel, pounds of conductor, insulation, ducting, tank size, etc. The software also provided information pertaining to the labor necessary to construct the transformer, including the number of turns in the windings and core dimensions including stack height. All the components from this bill of materials and labor estimate were then combined with fixed hardware costs such as bushings, busbar, and terminals. The Department then applied manufacturer markups to allow for scrap, handling, factory overhead, and non-production markups to estimate the manufacturer selling price. Detail on the derivation of the manufacturer selling prices and discussion of manufacturer markups used appears in the engineering analysis (Chapter 5). The Department derived the manufacturer's production cost inputs for the GRIM from the engineering analysis databases.

12.3.6 Conversion Costs

Efficiency standards typically cause manufacturers to incur conversion costs prior to the standard effective date in order to bring their production facilities and product designs into compliance with the standard. For the purpose of the MIA, DOE classified these conversion costs into two major categories. Conversion capital expenditures are investments in property, plant, and equipment to adapt or change existing production facilities so that new product designs can be fabricated and assembled under the standard. Product conversion expenses relate to research, development, testing, and marketing that aims to make product designs comply with the new efficiency standard. Conversion costs specific to each superclass are discussed separately in each of the following sections for liquid-immersed, LV dry-type, and MV dry-type distribution transformers.

12.3.7 Markup Scenarios

In order to estimate the manufacturer selling price of distribution transformers sold, the Department applied markups to the production costs. In an effort to gather information on industry pricing scenarios, the DOE invited manufacturers to discuss how standards might change the industry's profits. Manufacturers and DOE discussed issues such as the impact of higher core steel prices and transformer pricing scenarios to obtain manufacturers' insights as to how increased production costs under standards might be passed on to their customers. All of the manufacturers interviewed had applied one or more price increases within the last two years in order to recover some of the production cost increases resulting from higher commodity prices. A few of the larger manufacturers recently established pricing contracts with their customers which had a base price and then a variable "surcharge." The surcharge is adjusted on a periodic (e.g., monthly or quarterly) basis, and is calculated based on the transformer manufacturer's major input materials costs (e.g., core steel). All manufacturers discussed the recent material price increases within the context of the Department's questions about markups.

For the MIA, the Department considered two distinct markup scenarios, which are discussed in the following sections.

12.3.7.1 Preservation of Gross Margin Percentage Scenario

Under the preservation of gross margin percentage scenario, DOE applied a single uniform "gross margin percentage" markup across all efficiency levels. As production cost increases with efficiency, this scenario implies that the absolute dollar markup will increase. The non-production cost markup, which includes selling, general, and administrative expenses; research and development expenses; interest; and profit was assumed to be 1.25. This markup is consistent with the one that the Department assumed in the engineering analysis and the base case of the GRIM. Manufacturers believe it is optimistic to assume they would be able to maintain the same gross margin percentage markup as their production costs increase in response to an efficiency standard. Therefore, the Department assumes that this scenario represents a high bound to industry profitability under an energy conservation standard.

12.3.7.2 Preservation of Operating Profit Scenario

Operating profit is defined as earnings before interest and taxes. The implicit assumption behind this markup scenario is that the industry can maintain or preserve its operating profit (in absolute dollars) after the standard. The industry would do so by passing its increased costs on to its customers without increasing its operating profits in absolute dollars. The Department implemented this markup scenario in the GRIM by setting the non-production cost markups at each TSL to yield approximately the same operating profit in both the base case and the standard case in the year after standard implementation (2011). This scenario is less optimistic than the preservation of gross margin percentage scenario. For this scenario, the financial metrics of return on sales (percent) and return on invested capital (ROIC) decline with increasing TSL, indicating reduced industry profitability. The non-production cost markups under this scenario are summarized in Table 12.3.2.

Table 12.3.2 Non-Production Cost Markups for the Preservation of Operating Profit Scenario

Trial Standard Level	Superclass		
	Liquid-Immersed	**LV Dry-Type**	**MV Dry-Type**
Base Case	1.250	1.250	1.250
TSL1	1.248	1.243	1.248
TSL2	1.246	1.239	1.247
TSL3	1.241	1.235	1.245
TSL4	1.239	1.227	1.240
TSL5	1.224	1.219	1.223
TSL6	1.209	1.219	1.223

12.4 MANUFACTURER IMPACT ANALYSIS - LIQUID-IMMERSED

The liquid-immersed transformer industry is characterized by a high degree of flexibility, total ownership cost evaluation, and sophisticated customers. Liquid-immersed customers typically use a cost of ownership evaluation (see the Total Ownership Cost section of Chapter 5), which minimizes the sum of first cost and the present value of future core and coil losses that a given transformer will experience over its lifetime. Because these evaluation formulae vary from customer to customer, and because material prices fluctuate on a daily basis, the liquid-immersed industry evolved to be inherently flexible and responsive to customer needs.

As the Department understands it, there are approximately 25 companies active in the liquid-immersed market in the U.S., some of which are branding units manufactured by another company. The Department estimates that the nine or so largest liquid-immersed transformer manufacturing companies collectively control 90 percent of the market or more. They are (in alphabetical order): ABB, Central Maloney, Cooper Power, ERMCO, GE Prolec, Howard Industries, Kuhlman Electric, Pauwels, and Power Partners. Of these, the Department estimates that the top three companies supply approximately 60% of the liquid-immersed market. For more information on the transformer market, refer to the Market and Technology Assessment (Chapter 3).

12.4.1 Conversion Capital Expenditures

Through its interviews with manufacturers, the Department learned that the conversion capital expenditures that liquid-immersed transformer manufacturers would have to make in response to an energy conservation standard fall into three major categories: 1) annealing furnace capacity, 2) core-cutting and core-winding equipment, and 3) miscellaneous, including buildings and coil winding equipment. Manufacturers of liquid-immersed transformers provided capital cost estimates for each of these capital expenditure categories. The Department used the estimates provided by industry for comparative purposes and prepared its own bottom-up estimates of conversion capital expenditures. The bottom-up estimates are based on the Department's understanding of typical manufacturing processes at liquid-immersed facilities. This understanding is based on manufacturer interviews and discussions with suppliers of equipment to the industry. Typical equipment throughput and cost information was obtained directly from equipment suppliers and reconciled with information provided by manufacturers. Furthermore, transformer design parameters that vary with efficiency level (e.g., core weight) were obtained from the Department's engineering analysis and used to estimate the equipment capacity increases associated with increasing efficiency.

In the liquid-immersed superclass, TSLs 1 through 4 would require only conventional electrical steels. In contrast, TSL6 would require all of the liquid-immersed design lines to convert to amorphous core technology. TSL5 would require three of the five liquid-immersed design lines (DL3 - DL5) to convert to amorphous core technology. During the interviews, manufacturers discussed several reasons why, although technologically feasible, amorphous material is, in their opinion, not a good technology option for regulatory consideration:

1. Possible difficulty of access to the technology, including very limited sourcing options,

2. Concerns over availability of amorphous-core material at quantities necessary to meet industry demand,

3. The high level of capital equipment investment required (and the stranding of existing assets, particularly core-cutting equipment and annealing furnaces), and

4. Increased complexity associated with material processing and handling.

Thus, the Department recognizes that the manufacturing process for amorphous core transformers is completely different from that for silicon steel transformers. TSL6 would obsolete a large portion of the liquid-immersed manufacturing equipment, primarily the core-cutting equipment and the annealing furnaces. The Department estimates that the industry's stranded assets at TSL6 would represent a loss of approximately $59 M. TSL5 would not obsolete as much equipment as TSL6 because TSL5 would only require a conversion to amorphous core technology for three of the five design lines. The Department estimates that the industry's stranded assets at TSL5 would represent a loss of approximately $16 M. The Department's stranded asset estimates represent lower bounds to the book values of obsolete core-cutting equipment, annealing furnaces, and miscellaneous equipment such as conveyers and fixturing at each TSL.

The Department recognizes that TSL5 has the potential to severely distort and disturb both liquid-immersed product purchase decisions across design lines and manufacturers' operations. These distortions would arise because some design lines would necessarily be constructed with amorphous cores but some would still be designed with conventional grain-oriented electrical steels. A significant burden, which is difficult to quantify using the GRIM, would be placed on industry if it had to maintain parallel manufacturing operations for both conventional and amorphous core technology.

Based on the manufacturer interviews, TSLs 5 and 6 would cause liquid-immersed transformer manufacturers to decide whether they would tool for amorphous technology, attempt to purchase assembled amorphous cores, or exit the industry. If manufacturers were to choose to produce amorphous cores themselves, manufacturers indicated that they would face a critical decision about whether or not to relocate outside of the U.S., since much of their equipment would become obsolete.

The additional annealing furnace capacity that the industry would need at TSLs 1 through 4 is directly related to the increase in wound core mass that would be processed by the industry at each TSL. The Department assumed that a typical conventional annealing furnace that can process 6,000 tons of core steel per year has an installed cost of $2.2 M. Based on the engineering analysis and those designs selected by the LCC analysis customer choice model, the Department estimated increases in wound core mass processed at TSLs 1 through 4 to be 2 percent, 4 percent, 8 percent, and 9 percent, respectively. For TSL5, no additional conventional annealing furnace capacity would be necessary because some of the annealing furnaces currently used for DL3-DL5 would become available for use in DL1-DL2 (this transfer of capacity is also accounted for in the Department's stranded asset estimate above to avoid overestimation of stranded assets). For TSL6, no additional conventional annealing furnace capacity would be necessary because all production would convert to amorphous core technology. The Department estimated that conventional annealing furnace capital expenditures for the industry would be $2.2 M, $4.4 M, $6.6 M, and $6.6 M for TSLs 1 through 4, respectively, as shown in Table 12.4.1.

Table 12.4.1 Summary of Liquid-Immersed Distribution Transformer Conventional Annealing Furnace Capital Expenditures

Trial Standard Level	**Additional Wound Core Mass (Tons/yr)**	**Additional Annealing Furnaces Needed by Industry**	**Annealing Furnace Conversion Capital Expenditure (2004$, Millions)**
TSL1	3,359	1	2.2
TSL2	8,555	2	4.4
TSL3	15,090	3	6.6
TSL4	17,458	3	6.6

The new amorphous annealing furnace capacity that the industry would need at TSLs 5 and 6 is directly related to the amorphous core mass that would be processed by the industry at each TSL. Based on information obtained from liquid-immersed transformer manufacturers and annealing furnace suppliers, the Department estimated that a typical amorphous annealing furnace, which can process 1,005 tons of core steel per year, has an installed cost of $0.54 M. The Department estimated that amorphous annealing furnace capital expenditures for the industry would be $52.4 M and $149.6 M for TSLs 5 and 6, respectively, as shown in Table 12.4.2.

Table 12.4.2 Summary of Liquid-Immersed Distribution Transformer Amorphous Annealing Furnace Capital Expenditures

Trial Standard Level	**Amorphous Core Steel Mass (Tons/yr)**	**Amorphous Annealing Furnaces Needed by Industry**	**Amorphous Annealing Furnace Conversion Capital Expenditure (2004$, Millions)**
TSL5	96,700	97	52.4
TSL6	278,101	277	149.6

The Department assumed that the additional conventional core-cutting equipment required by the industry for TSLs 1 through 4 is directly related to the increase in core weight at each TSL. Based on discussions with a leading supplier of wound core-cutting equipment to the liquid-immersed superclass, the Department calculated the processing capacity of a distributed-gap core winding machine. This equipment supplier estimates that a new machine can process 150 ft/min of M6 core steel, which translates into 2,510 lbs/hr of core steel. Allowing for set-up, wound core removal and down-time, the Department applied a 75% utilization on this processing speed, resulting in a single core-cutting machine being capable of processing about 1,883 lbs/hr of core steel. Furthermore, the Department assumes that the core-cutting machines operate two shifts per day, 250 days per year. One of these core-cutting and winding machines costs approximately $200 k installed.

The Department's assumption that the increase in conventional core-cutting capacity required at each of TSLs 1 through 4 is best approximated using the increases in core weight at each TSL is based on dialogue with the aforementioned leading equipment supplier. Standard core-cutting equipment used by liquid-immersed manufacturers operates at varying linear rate depending on lamination thickness and strip width. The machines maintain approximately a constant processing throughput in terms of weight, irrespective of thickness and strip width. For each design line, the Department estimated the increases in core steel weight processed at each TSL using the engineering analysis and the designs selected by the LCC analysis customer choice model. Table 12.4.3 provides detail explaining the estimate of additional core-cutting machines needed at each TSL.

Table 12.4.3 Summary of Additional Core-Cutting Machine Estimate for Liquid-Immersed Superclass

Design Line	DL1	DL2	DL3	DL4	DL5	Additional Core-Cutting Machines, Liquid-Immersed
Approximate Number of Core-Cutting Machines in Base Case	11.3	19.3	0.9	6.5	8.9	0
Ratio of TSL1 Core Weight to Base Case Core Weight	1.009	1.006	1.008	1.040	1.031	1
Ratio of TSL2 Core Weight to Base Case Core Weight	1.009	1.016	1.026	1.120	1.072	2
Ratio of TSL3 Core Weight to Base Case Core Weight	1.009	1.026	1.110	1.220	1.120	4
Ratio of TSL4 Core Weight to Base Case Core Weight	1.065	1.026	1.183	1.220	1.132	5

Notes: The above matrix is used to estimate the number of core-cutting machines required for TSLs 1-4. The additional machines (above the 47 machines required for the base case) are obtained by difference. For example, at TSL1: $(1.009\times11.3) + (1.006\times19.3) + (1.008\times0.9) + (1.040\times6.5) + (1.031\times8.9) - 47 = 1$ machine (rounded up).

The Department estimated that core-cutting equipment capital expenditures for the superclass would be \$0.2 M, \$0.4 M, \$0.8 M and \$1.0 M for TSL1 through TSL4, respectively. These capital outlays are relatively small compared to those that the industry would incur to expand annealing furnace capacity. The core-cutting equipment estimates are summarized in Table 12.4.4.

Table 12.4.4 Summary of Liquid-Immersed Distribution Transformer Conventional Core-Cutting Equipment Capital Expenditures

Trial Standard Level	**Additional Core-Cutting Machines Needed by Industry**	**Core-Cutting Conversion Capital Expenditure (2004$, Millions)**
TSL1	1	0.2
TSL2	2	0.4
TSL3	4	0.8
TSL4	5	1.0

The Department estimated the amorphous core-cutting capacity at TSLs 5 and 6 based on the total weight of amorphous core steel projected to be processed at each TSL. Based on discussions with amorphous core-cutting equipment suppliers and transformer manufacturers, the Department estimates that a typical amorphous core-cutting machine can process 1,250 lbs/hr of core steel. The Department applied a 75% utilization on this processing speed, resulting in a single core-cutting machine being capable of processing about 938 lbs/hr of core steel. Furthermore, the Department assumes that the core-cutting machines would operate two shifts per day, 250 days per year. One of these amorphous core-cutting machines costs approximately $500 k installed. The Department estimated that amorphous core-cutting equipment capital expenditures for the superclass would be $26.0 M and $74.5 M for TSL5 and 6, respectively. The amorphous core-cutting equipment estimates are summarized in Table 12.4.5.

Table 12.4.5 Summary of Liquid-Immersed Distribution Transformer Amorphous Core-Cutting Equipment Capital Expenditures

Trial Standard Level	**Number of Amorphous Core-Cutting Machines Needed by Industry**	**Amorphous Core-Cutting Conversion Capital Expenditure (2004$, Millions)**
TSL5	52	26.0
TSL6	149	74.5

For TSLs 1 through 4, the Department estimated miscellaneous capital investments, primarily buildings and coil winding equipment, based on a multiplier approach. With respect to buildings, the manufacturers indicated that additional building space will be necessary in some cases to accommodate expanded annealing furnace capacity. With respect to coil winding equipment, the Department understands that as transformers become more energy efficient, manufacturers may switch from winding coils with aluminum conductor to copper. Copper has a higher conductivity, allowing for smaller cross-sectional areas and transformer cores. However, copper requires more torque when winding in order to ensure the same winding quality. The higher torque can be met by slowing existing machines or winding fewer coils simultaneously. In both scenarios, additional coil-winding capacity is required. To estimate the total conversion capital investments, including those required for buildings and coil winding equipment, the Department applied a multiplier of 1.05 to the sum of the explicitly estimated core-cutting and annealing furnace capital expenditures. The 1.05 multiplier is based on information submitted by industry.

For TSLs 5 and 6, before applying a multiplier to the explicitly estimated amorphous core-cutting and annealing furnace capital expenditures, the Department estimated the costs of converting the portion of the liquid-immersed industry that uses shell designs to core form designs. For TSL5, since the single-phase design lines would not have to convert to amorphous core technology, the costs of converting to core form designs would be zero. For TSL6, the Department estimates the costs of converting the liquid-immersed industry fully to core form designs to be $48 M. This estimate includes $6 M for lacing tables and $42 M for coil winding equipment. After adding these costs of converting to core form designs to the previously tabulated amorphous core-cutting and annealing furnace estimates, the Department applied an assumed multiplier of 1.2 at TSL5 and TSL6 to account for the cost of conveyers, fixturing, tank washers, hangers, buildings, etc. The total conversion capital expenditures for the liquid-immersed superclass are summarized in Table 12.4.6.

Table 12.4.6 Summary of Liquid-Immersed Distribution Transformer Conversion Capital Expenditures

Trial Standard Level	Annealing Furnace Conversion Capital Expenditure (2004$, Millions)	Core-Cutting Conversion Capital Expenditure (2004$, Millions)	Miscellaneous, incl. Buildings and Coil Winding Equipment	Total Conversion Capital Expenditure (2004$, Millions)
TSL1	2.2	0.2	0.1	2.5
TSL2	4.4	0.4	0.2	5.0
TSL3	6.6	0.8	0.4	7.8
TSL4	6.6	1.0	0.4	8.0
TSL5	52.4	26.0	15.7	94.1
TSL6	149.6	74.5	*102.4	326.5

* Includes $48 M to fully convert industry from shell to core form designs.

12.4.2 Product Conversion Expenses

Product conversion expenses include engineering, prototyping, testing, and marketing expenses incurred by a manufacturer as it prepares to come into compliance with a standard. The Department assumes that product conversion expenses for liquid-immersed transformer manufacturers at TSLs 5 and 6 will require total additional expenses equivalent to 100 percent of the industry's R&D budget for three years. Since manufacturers already produce liquid-immersed transformers that would comply with TSLs 1 through 4, product conversion expenses are expected to be negligible for these TSLs. Product conversion expenses are summarized in Table 12.4.7.

Table 12.4.7 Summary of Liquid-Immersed Distribution Transformer Product Conversion Expenses

Trial Standard Level	**Basis**	**Product Conversion Expenses (2004$, Millions)**
TSL1-4	Industry makes these designs today.	0
TSL5	Amount equivalent to 100% of industry R&D budget for 3 years.	109.2
TSL6	Amount equivalent to 100% of industry R&D budget for 3 years.	161.2

12.4.3 Industry Financial Impacts

The Department used the GRIM and the inputs and assumptions described in the previous sections to produce indicators of financial impacts on the liquid-immersed distribution transformer superclass at each TSL. This document reports the results of the MIA using two key financial metrics: INPV and annual net cash flow to the industry.

12.4.3.1 Trial Standard Levels

The Department developed six TSLs for the liquid-immersed distribution transformer superclass. TSL1 is the NEMA TP-1 standard. TSL6 represents the maximum TSL that is technologically feasible. TSLs 2 through 5 are bundles of various candidate standard levels as described in Chapter 10 (section 10.2.2.3) of this Technical Support Document. TSL6 would require all liquid-immersed design lines to convert to amorphous core technology. TSL5 would require design lines 3 through 5 to convert to amorphous core technology.

12.4.3.2 Impacts on Industry Net Present Value

The INPV measures the industry value and is used in the MIA to compare the industry-wide economic impacts of different TSLs. The INPV is different from the Department's NPV applied to the whole U.S. economy. The INPV is the sum of all net cash flows discounted at the industry's cost of capital or discount rate. The Department used the GRIM to estimate cash flows between 2004 and 2038, consistent with the forecast period used in the national impact analysis.

In the manufacturer impact analysis, the Department compared the INPV of the base case (no efficiency standard) to that of each TSL. The difference in INPV is an estimate of the economic impacts that implementing each particular TSL would have on the entire industry.
To evaluate the range of cash flow impacts on the industry, the Department constructed two MIA analyses based on the two markup scenarios discussed in section 12.3.7. In the first scenario, the gross margin percentage is held constant at all TSLs (and equal to the base case gross margin

percentage). In the second scenario, it is assumed that the industry could preserve its operating profit at all TSLs. Tables 12.4.8 and 12.4.9 provide the INPV estimates under the two scenarios.

Table 12.4.8 Changes in Liquid-Immersed Industry Net Present Value, Preservation of Gross Margin Percentage Scenario

Trial Standard Level	INPV (2004$, Millions)	Change in INPV from Base Case	
		2004$, Millions	% Change
Base Case	$526	-	-
TSL1	$532	$5.8	1.1%
TSL2	$537	$10.7	2.0%
TSL3	$553	$27.0	5.1%
TSL4	$561	$34.9	6.6%
TSL5	$549	$22.3	4.2%
TSL6	$552	$25.8	4.9%

Table 12.4.9 Changes in Liquid Immersed Industry Net Present Value, Preservation of Operating Profit Scenario

Trial Standard Level	INPV (2004$, Millions)	Change in INPV from Base Case	
		2004$, Millions	% Change
Base Case	$526	-	-
TSL1	$521	($5.7)	-1.1%
TSL2	$513	($12.9)	-2.4%
TSL3	$496	($30.0)	-5.7%
TSL4	$490	($36.9)	-7.0%
TSL5	$323	($203.8)	-38.7%
TSL6	$27	($499.6)	-94.9%

The results from the preservation of gross margin percentage scenario provide a more favorable projection than do the results from the preservation of operating profit scenario. Industry value would increase if manufacturers could sustain their gross margin percentage as their production costs increase in response to a standard. However, as previously mentioned, the preservation of gross margin percentage assumption may be optimistic, particularly at higher TSLs.

The preservation of operating profit markup scenario provides a low bound for INPV under a standard. The decrease in industry value under this scenario comes from the inability of industry to fully recoup the capital investments required for standard compliance, including investments in working capital. The negative impacts on INPV are much greater at TSL5 and TSL6, which are the two TSLs that would require partial or full conversion of the industry to amorphous core technology.

12.4.3.3 Impacts on Annual Cash Flow

While INPV is useful for evaluating the long-term effects of standards, short-term changes in net cash flow are also important and indicative of the impacts on industry during the years between final rule publication and the standard effective date. For example, a large investment over a period of a few years could strain the industry's access to capital. Consequently, the sharp drop in net cash flow might lead to additional borrowing; changes in leverage, interest coverage ratios, and/or bond ratings; and possibly increased concern among investors. Thus, a short-term disturbance can have long-term effects that the INPV cannot capture. To get an idea of the behavior of annual net cash flows, the Department reports the annual net or free cash flows from 2004 through 2020 for the different TSL levels. Figures 12.4.1 and 12.4.2 present the annual net cash flows for the base case and each of the six TSLs evaluated for the two different markup scenarios.

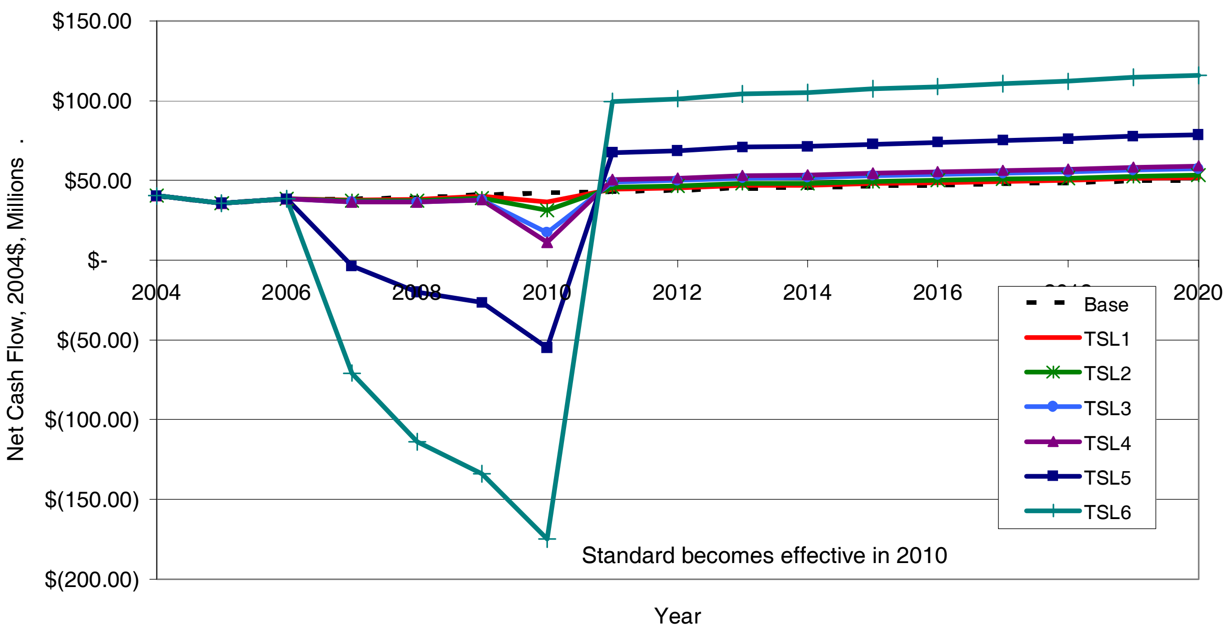

Figure 12.4.1 Industry Net Cash Flow for Preservation of Gross Margin Percentage Scenario, Liquid-Immersed

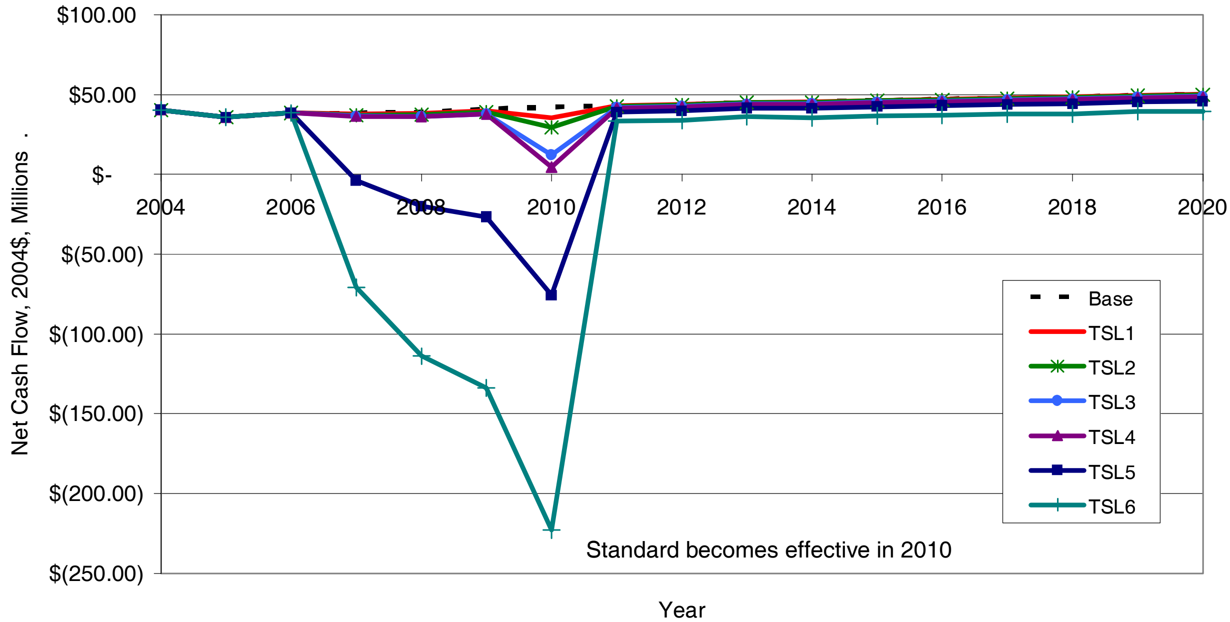

Figure 12.4.2 Industry Net Cash Flow for Preservation of Operating Profit Scenario, Liquid-Immersed

Prior to the final rule publication date, the cash flows are identical for all TSLs in both scenarios. After final rule publication, cash flows are driven by the level of capital investments and product conversion expenses and the proportion of these investments spent every year. In addition, in the year of the standard, a relatively large investment in working capital is required. The incremental investments in working capital are about $7 M, $13 M, $30 M, $38 M, $123 M, and $284 M for TSLs 1 through 6, respectively (with about 5-6 percent variation at each TSL between markup scenarios). After final rule publication, industry cash flows begin to decline as industry uses its financial resources to prepare for the standard. In the year the standard becomes effective, new capital equipment goes into production.

While the behavior of cash flows for each TSL varies between the two markup scenarios, there are three observations that are common across the two scenarios. First, the net annual cash flows do not go negative for TSL1 through TSL4. Second, for TSL3 and TSL4, net annual cash flows dip close to zero in 2010, the year of standard implementation. The dip in cash flow in 2010 is due to a relatively large investment in working capital that would be required to finance increased inventories, accounts receivable, etc. Third, net annual cash flows go negative during the compliance period for TSL5 and TSL6, which are the two TSLs that would require a partial or full conversion to amorphous core technology.

12.4.4 Other Impacts

12.4.4.1 Employment

Industry-wide labor expenditures are estimated based on the engineering analysis. Winding of the primary and secondary coils; cutting, forming and annealing of the core; core assembly; testing; and packing of the completed transformer represent the bulk of the labor. The Department incorporated these assumptions into the GRIM, which projects labor expenditures annually. Labor expenditures are a function of the labor intensity of the product, the sales volume, and an implicit wage assumption that remains fixed in real terms over time. Table 12.4.10 provides the changes in labor measured as the change in labor expenditures for liquid-immersed transformers in 2010, the standard effective date, versus the base case.

Table 12.4.10 Projected Change in Labor Expenditures, Liquid-Immersed (2010)

Trial Standard Level					
TSL1	**TSL2**	**TSL3**	**TSL4**	**TSL5**	**TSL6**
3.1%	3.2%	0.8%	1.2%	34.9%	98.8%

Based on the GRIM and the assumption that 95 percent of liquid-immersed transformers sold in the U.S. are manufactured in the U.S., the Department estimates that there are currently 4,247 production employees in the U.S. liquid-immersed distribution transformer industry. This estimate excludes non-production workers and assumes a level annual production rate. In practice, including non-production workers and seasonal effects, the actual number of employees in the liquid-immersed superclass would be higher. Due to the fact that labor content does not vary between the markup scenarios, projected labor expenditures are equivalent for both. Based on these results, DOE expects no significant discernable direct employment impacts among transformer manufacturers for TSL1 through TSL4, but potentially large increases in employment for TSL5 and TSL6. These conclusions are independent of any conclusions regarding employment impacts from the broader U.S. economy, which are documented in Chapter 14 of this Technical Support Document. These conclusions also ignore the possible relocation of domestic employment to lower labor cost countries such as Mexico. Also, for TSLs 5 and 6, this conclusion ignores the possibility of outsourcing amorphous core production to companies in other countries such as India.

Manufacturers expressed concern during the MIA interviews that establishing an energy conservation standard would ‘commoditize' the distribution transformer market, making it easier for foreign manufacturers who specialize in low-cost mass production of one design to enter the U.S. market. Today's liquid-immersed market is characterized by total ownership cost evaluation formulae and customer design requirements and specifications. U.S. manufacturers differentiate themselves in the market by employing rapid turn-around times and demonstrating responsiveness to their customer needs. According to some manufacturers, in Massachusetts where a state standard of NEMA TP-1 was passed for both liquid-immersed and dry-type transformers, several utilities have abandoned their evaluation formulae and simply ordered standards-compliant transformers. In many cases, according to manufacturers, these standards-complaint units are less efficient than those that were purchased before the state standard took effect. In other words, according to manufacturers, there has been a backsliding in average efficiency in this market, and an associated ‘commoditization’ of the product offering which has opened the door to foreign competition. Industry fears this situation will worsen under a federal standard. This concern was independently raised by several liquid-immersed manufacturers during the MIA interviews and represents a critical concern in the industry.

U.S. manufacturers believe that they could be impacted from ‘commoditization’ in several ways. Less efficient transformers are smaller and less costly; therefore, ‘commoditization’ could result in reduced capacity utilization and lower revenues. Increased competition from foreign manufacturers could result from U.S. manufacturers’ loss of competitive advantage, which today is derived from the flexibility of U.S. manufacturing processes and product customization capabilities. Finally, manufacturers believe they may have no alternative other than to relocate their facilities outside of the U.S. to compete on an equal basis with lower labor cost foreign producers. In essence, after an energy conservation standard, manufacturers believe that the liquid-immersed distribution transformer industry would begin to more closely resemble today’s LV dry-type market.

12.4.4.2 Production Capacity

The Department believes that there are only minor production capacity implications for the standard at TSL4 and below. At TSL6, all liquid-immersed design lines would have to convert to amorphous core technology. At TSL5, three design lines would have to convert to amorphous core designs. Conversion to amorphous core designs would obsolete a large portion of the equipment used in the liquid-immersed industry (e.g., annealing furnaces, core-cutting and winding equipment).

12.4.4.3 Exports

Domestic manufacturers produce and export liquid-immersed transformers around the world. Due to the inherent manufacturing flexibility built into their production lines, manufacturers can readily retool and build export units (even 50 Hz fundamental frequency) without problem. Once the standard takes effect, transformer manufacturers would still be able to produce and export units that are below the Department’s minimum efficiency standard, as the standard only applies to transformers for use in the United States.

During the MIA interviews, one manufacturer expressed concern that an existing volume discount enjoyed on a low-grade grain-oriented steel that the manufacturer uses to build transformers for export may no longer be available if the Department’s standard drives the minimum efficiency to a point where M3 or M2 core steel become the primary steels used by the U.S. transformer industry. In this way, exported transformers that have lower quality steel may become slightly more expensive and therefore less competitive globally. The Department recognizes this concern, but does not expect its impact to significantly degrade the existing export market.

12.4.4.4 Cumulative Regulatory Burden

While any single regulation may not impose a significant burden on manufacturers, the combined effects of several regulations, existing or pending, may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Assessing the impact of a single regulation may overlook this cumulative regulatory burden.

Companies that produce a wider range of regulated products may be faced with more capital and product development expenditures than their competitors. This can prompt those companies to exit the market or reduce their product offerings, potentially reducing competition. Smaller companies can be especially impacted since they have lower sales volumes over which to amortize the costs of meeting new regulations. The Department considers that a proposed standard is not economically justified if it contributes to an unacceptable level of cumulative regulatory burden.

The Department looked at three areas of regulatory burden: 1) Federal, 2) State, and 3) Other regulations and standards.

1. <u>Federal Regulations on Distribution Transformer Manufacturers</u> - in addition to potential efficiency regulations on distribution transformers, the National Energy Code (NFPA 70) places additional restrictions on liquid-immersed transformers, requiring that indoor liquid-immersed transformers be located in separate transformer vaults. Furthermore, the code provides stipulations for fire walls, doors, ventilation, and oil containment, increasing the installed cost of these types of transformers. The impetus for this section of the National Energy Code is to prevent fires associated with flammable insulating fluids, however this mandate applies to all indoor liquid-immersed transformers, including those containing non-flammable liquid products.

2. <u>Regulations and Pending Regulations at the State Level</u> - manufacturers also discussed the recent trend of state governments to implement NEMA TP-1 as a mandatory standard for transformers sold within state borders. At this time, the Department knows of one state that requires this minimum efficiency standard for liquid-immersed distribution transformers. These standards, when preempted by federal energy efficiency regulation, will not create a cumulative burden on domestic manufacturers.

3. <u>Other Regulations and Standards</u> - manufacturers were not aware of other regulations or standards, in effect or pending, which affect liquid-immersed distribution transformers.

12.4.4.5 Impacts on Small Businesses

The Small Business Administration defines a small business, for the distribution transformer industry, as a business that has 750 employees or fewer. The Department estimates that of the approximately 25 U.S. manufacturers that make liquid-immersed distribution transformers, about 15 of them are small businesses. About one-third of the small businesses have fewer than 100 employees.

Because the liquid-immersed distribution transformer superclass largely produces customized transformers, small businesses can compete because each unique design is produced in relatively small volumes for a given order. Implementation of an energy conservation standard would have a relatively minor differential impact on small liquid-immersed distribution transformer manufacturers. Disadvantages to small business such as having little leverage over suppliers (e.g., core steel suppliers) are present with or without an energy conservation standard.

12.4.4.6 Worker Safety

During the interviews, manufacturers expressed concern for their workers, who handle heavy material and equipment on a daily basis while producing transformers. For manufacturing industries like distribution transformers, the Occupational Safety and Health Administration (OSHA) established a maximum handling weight of 70 pounds per worker. As transformers become larger and more energy efficient, the core material will get heavier, coils will become heavier, and tanks and enclosures will increase in size. Bearing this in mind, plant managers are acutely aware and concerned about the fact that as weights increase, so do accident frequencies.

12.4.4.7 Other Engineering Issues

Manufacturers are concerned that the dimensionally constrained transformers they produce today may be difficult or perhaps impossible to build to meet standards. For example, for round-tank liquid-immersed transformers (design line 3), they indicated that going above TSL3 would be problematic due to the size of the transformer exceeding the capacity of the industry-standard pole-mounting brackets. According to manufacturers, these transformers hit their maximum height at TSL2 (between the power lines overhead and the telephone and cable lines underneath), and thus all size expansion at higher TSLs is in the diameter of the tank. Approximately 80 percent of overhead transformers sold are for replacement installations, so this issue of a pre-existing space limit will cause problems for utilities and may increase outage times.

Manufacturers also expressed concern over a second dimensionally constrained liquid-immersed transformer - subsurface retrofit transformers. These liquid-immersed units are designed to be installed within an existing concrete vault to service an underground distribution network. If the efficiency standard is significantly different from the levels being built today, it may require substantial (extremely expensive) rework of these vaults, increasing downtime or stress on the local distribution network while a failed unit is replaced.

12.4.5 Summary of Impacts for Liquid-Immersed Superclass

The electric utility industry appears to be making mostly evaluated transformer purchase decisions. However, in the state that has adopted an energy conservation standard for liquid-immersed distribution transformers, the average efficiency of the purchased transformers is reported by manufacturers to be in decline. The explanation for this counterintuitive trend, as reported by several manufacturers, is that after the efficiency standards were implemented, electric utilities abandoned their evaluation formulae and simply have purchased the least-expensive standards-compliant transformers. This backsliding may result in ‘commoditization’ of liquid-immersed transformers, ultimately making it easier for foreign competition to compete in the U.S. liquid-immersed market. Manufacturers fear that this situation may worsen under a federal standard.

TSL6 would require all liquid-immersed design lines to convert to amorphous core technology. TSL5 would require three of the five liquid-immersed design lines to convert to amorphous core technology. Since the manufacturing process for amorphous core transformers is completely different from that for conventional transformers, TSLs 5 and 6 would obsolete a significant portion of U.S. industry's equipment. The Department estimates the stranded assets for TSL5 and TSL6 to be $16 M and $59 M, respectively. In addition, manufacturers detailed many technical reasons why amorphous core material is difficult and potentially hazardous for workers.

TSL4 can be met without using amorphous core technology. However, manufacturers expressed concerns over meeting TSL4 while simultaneously being able to meet customer specifications including size and weight limitations.

Conversion capital expenditures in the liquid-immersed distribution transformer superclass include primarily expanded annealing furnace capacity, but also additional core-cutting equipment, coil-winding equipment, and building construction. The need for additional annealing furnace capacity and core-cutting equipment is driven by the increase in core weights that would be experienced at higher TSLs. Conversion capital expenditures would be relatively modest for TSL1 through TSL4, ranging from $2.5 M (TSL1) to $8.0 M (TSL4) in an industry with projected revenue of $1.4 B in 2007. The industry would experience negligible product conversion expenses in the TSL1 to TSL4 range because products meeting these efficiency levels are produced in significant quantities today. Conversion capital expenditures and product conversion expenses would be substantially higher for TSL5 and TSL6, the standard levels that would require partial or full conversion to amorphous core technology. The Department estimates that conversion capital expenditures would be $94.1 M and $326.5 M for TSL5 and TSL6, respectively. The Department estimates the corresponding product conversion expenses to be $109 M and $161 M, respectively.

The impact on INPV at TSL6 ranges between -94.9 percent and +4.9 percent, depending upon the assumed markup scenario. There is a great deal of uncertainty in these impact estimates, primarily due to uncertainty around transformer pricing at high TSLs. At TSL6, the magnitude of the peak negative net annual cash flow would be more than three times that of the positive base case cash flow.

The impact on INPV at TSL5 ranges between -38.7 percent and +4.2 percent, depending upon the assumed markup scenario. There is a great deal of uncertainty in these impact estimates, primarily due to uncertainty around transformer pricing at high TSLs. At TSL5, the magnitude of the peak negative net annual cash flow would be about equal to that of the positive base case cash flow. A significant burden, which is difficult to quantify using the GRIM, would be placed on industry if it had to maintain parallel manufacturing operations for both conventional and amorphous core technology under TSL5.

The impact on INPV at TSL4 ranges between -7.0 percent and +6.6 percent, depending upon which markup scenario is assumed. The impact on annual net cash flow would be significant at TSL4, bringing net cash flow nearly to zero in 2010 in a low markup scenario. The 2010 impacts would largely be driven by the need to invest in working capital. Although cash flow impacts would be significant at TSL4, the industry would likely recover from them in the years following standard implementation.

The impact on INPV at TSL3 ranges between -5.7 percent and +5.1 percent, depending upon which markup scenario is assumed. The impact on annual net cash flow would be significant at TSL3, bringing net cash flow nearly to zero in 2010 in a low markup scenario. The 2010 impacts would largely be driven by the need to invest in working capital. Although cash flow impacts would be significant at TSL3, the industry would likely recover from them in the years following standard implementation.

At TSL2, the impact on INPV ranges between -2.4 percent and +2.0 percent. The impact on annual net cash flow would be small at TSL2.

At TSL1, the impact on INPV ranges between -1.1 percent and +1.1 percent. The impact on annual net cash flow would be negligible at TSL1.

Finally, there are several additional factors to be considered from the standpoint of manufacturers in selecting the proposed standard:

1. If the liquid-immersed standard is high relative to the standard for MV dry-type transformers, there could be a switch to MV dry-type transformers for certain products where there is substitutability between the superclasses. For reasons related to the properties inherent in their operation, for equivalent kVA ratings and TSLs, the efficiency levels of MV dry-type transformers are lower than those of liquid-immersed.

2. If the standard is set above a certain level, some customers may look for loop-holes in the Department's definition of a distribution transformer through which it can circumvent the standard. If a speciality or niche application transformer exempted from standards is less expensive than a standards-complaint distribution transformer, these customers may purchase a standards-exempt transformer which is also capable of serving a distribution function.

3. Several manufacturers expressed concern about enforcement. Many manufacturers urged the Department to make enforcement a top priority to ensure an effective standard.

4. At TSL2 and higher, certain high fire-point products might become uncompetitive.

5. Differential impacts on small businesses do not appear to be important for the liquid-immersed distribution transformer superclass.

6. Manufacturers mentioned maximum practical efficiencies based on dimensional, weight, and other practical limitations. The practical maxima reported to the Department fell in the range of 99.4 to 99.5 percent for liquid-immersed transformers.

7. Manufacturers relayed concerns about utility capital budgets. If standards go above a certain level, the capital budgets for distribution transformers might not be able to accommodate the transformer price increases, thereby creating downward pressure on manufacturer profit margins.

12.5 MANUFACTURER IMPACT ANALYSIS - LOW-VOLTAGE DRY-TYPE

The LV dry-type market is characterized by several features which have a large bearing on the manufacturer impacts at the various TSLs. LV dry-type transformers are sold primarily and overwhelmingly on first cost. From a manufacturer perspective, they are relatively undifferentiated commodity products manufactured repeatedly using the same "cookie cutter" design. The industry is also characterized by a large number of manufacturers, most of them small. Several of the larger manufacturers have moved some (or all) of their production outside the United States to reduce the labor cost component of finished units. Typical core steels used in this market include inefficient non-oriented steels, such as M19 and M36.

The Department is aware of more than 40 companies active in the LV dry-type market in the United States. These companies can be grouped into three tiers based on sales volume. Tier one companies include those who manufacturer and bundle switchgear with their transformers. There are three tier one companies - Cutler-Hammer, General Electric, and Square D. Tier two consists of eight or so smaller companies who mass produce catalogue / stock-item LV dry-type transformers. Companies in this tier include Acme Electric (Actuant), Federal Pacific, Jefferson Electric, Sola Hevi-Duty, Hammond, MGM, and Olsun. Finally, there are tier three companies that are smaller, and build some catalogue stock, but tend to be customer-focused, following detailed specifications and producing made-to-order units. The Department's database lists approximately 30 companies that fall into this third tier. The Department estimates that tier one companies, including other switchgear manufacturers that may not manufacture their own transformers, account for approximately 50 percent of sales. Tier two companies account for the vast majority of remaining product sales. As discussed further in this section, each tier, while facing many of the same technology issues, differs in its ability to finance and meet the investments needed to comply with the standard.

For information on the transformer market in general, and LV dry-type transformers in particular, refer to the Market and Technology Assessment (Chapter 3).

12.5.1 Conversion Capital Expenditures

Through the MIA interviews, the Department learned that there are two principal conversion capital expenditures that LV dry-type transformer manufacturers would have to make in response to a standard. These are: 1) investments in core-cutting equipment capable of making mitered cuts, and 2) investments in miscellaneous tooling and equipment including that used for coil winding. Core-cutting equipment capable of making mitered cuts is a key component of the LV dry-type analysis. Mitered construction techniques are often needed to reduce no-load losses in the cores of LV dry-type transformers. Mitered joints have lower destruction factors and are more efficient than conventional butt-lap joints.

Currently most "baseline" LV dry-type transformers are constructed using non-oriented electrical steel and are assembled in a butt-lap core configuration. Butt-lap joints do not require complex tooling, rather they involve simple 90 degree cuts and can be performed using inexpensive tooling. Manufacturers have commented repeatedly, and the Department's engineering analysis confirms, that TSL1 (NEMA TP-1) was established at a level attainable using grain-oriented M6 core steel and butt-lap construction. Currently, manufacturers can costcompetitively trade-off core construction techniques (and associated capital investments) and core steel quantities. For example, TSL1 can be achieved with butt-lap joints and relatively large amounts of M6 core steel at low flux density, or using mitered joints with less steel at a higher flux density. Effectively, capital investments in core-mitering equipment can be avoided and traded off for a variable cost penalty in the form of greater amounts of core steel with butt-lap designs. However, above TSL1, mitered cores (or wound cores) become the only cost-effective design path and at higher levels the only possible design path. Thus the manufacturing impacts in the LV dry-type superclass are primarily due to capital investments for mitered core-cutting equipment.

The Department's analytical approach to estimating the capital requirements for mitered core-cutting equipment relied on the engineering analysis and equipment vendor product information and costs. The Department estimated that the equivalent of three full-time mitered core-cutting machines are currently in use by the LV dry-type superclass. At TSL1, the Department estimated that 30 percent of the LV dry-type transformers would be manufactured using core-cutting equipment capable of making mitered cuts. At TSL2, the Department assumed that 95 percent of LV dry-type transformers would be manufactured using core-cutting equipment capable of making mitered cuts. At TSL3 and higher, mitered construction is necessary, thus all cores (in design lines 7 and 8) would be manufactured using core-cutting equipment capable of making mitered cuts.

The Department sent select designs from the engineering analysis to the primary supplier of mitered core-cutting equipment to help prepare an estimate of the processing time per machine. The equipment manufacturer estimates that each machine, working in a normal setting (accounting for set-up, processing, downtime), would process approximately two cores per hour, or sixteen cores per shift. This estimate applies to design lines 7 and 8 for processing TSL1-compliant transformer cores using M6 core steel in batches of five (design line 6 typically is not mitered). Each core-mitering machine is estimated to cost the LV dry-type distribution transformer superclass about $750 k installed plus $200 k for additional building space.

At TSL2 and higher, the processing time per core is higher than at TSL1, increasing the number of mitered-core cutting machines required by the superclass. The processing time per core increases for two reasons: 1) more core-cutting time is required as stack height increases with higher efficiencies, and 2) the processing time increases in inverse proportion to lamination thickness and more efficient grades of steel typically are thinner (e.g., lamination thickness changes from 0.014" for M6 to 0.009" for M3, representing a 56 percent increase in core-mitering time for M3). Some manufacturers report that their core-mitering equipment operates poorly with thinner steels, which would require them to operate at lower speeds, exacerbating the capacity impacts. Average core stack height and lamination thickness are based on the engineering analysis and the LCC analysis. Accounting for these increases in processing time per core, the Department estimated the number of mitered core-cutting machines required at TSL2 and higher. Table 12.5.1 shows an example calculation for the core-mitering capacity multiplier at each TSL for DL7, not accounting for the fraction of transformers that are mitered at each TSL.

Table 12.5.1 Calculation of Core-Mitering Capacity Multiplier for Design Line 7

Trial Standard Level	Typical Stack Height (in.)	Typical Lamination Thickness (in.)	Typical Number of Laminations per Inch (in. $^{-1}$)	*Multiplier for Increased Core-Mitering Capacity
TSL1	3.79	0.0140	71.4	1.00
TSL2	3.79	0.0140	71.4	1.00
TSL3	4.36	0.0090	111	1.79
TSL4	5.04	0.0090	111	2.07
TSL5/6	6.08	0.0090	111	2.50

* Based on the ratios of stack heights and number of laminations per inch, normalized to TSL1. For example, at TSL3, the multiplier is calculated as (4.36/3.79)×(111/71.4) = 1.79.

The Department estimates that 313,199 DL7 transformers would be sold in 2010 at TSL1. With the assumptions of 16 cores per shift, two shifts per day, and 250 operating days per year, the Department estimates that 39.1 core-mitering machines would be needed at TSL1 if every DL7 transformer was mitered. For DL8, the Department estimates that 22,731 transformers would be sold in 2010 at TSL1. With the assumptions of 16 cores per shift, two shifts per day, and 250 operating days per year, the Department estimates that 2.8 core-mitering machines would be needed at TSL1 if every DL8 transformer was mitered. Table 12.5.2 and Table 12.5.3 provide the calculation for the estimated number of core-mitering machines at each TSL for DL7 and DL8, respectively.

Table 12.5.2 Calculation of Core-Mitering Machines Needed for Design Line 7

Trial Standard Level	Multiplier for Increased Core-Mitering Capacity	Number of Core-Mitering Machines if all Transformers are Mitered	Fraction of Transformers that are Mitered	Number of Core-Mitering Machines
TSL1	1.00	39.1	0.30	11.7
TSL2	1.00	39.2	0.95	37.2
TSL3	1.79	70.0	1.00	70.0
TSL4	2.07	81.0	1.00	81.0
TSL5/6	2.50	97.7	1.00	97.7

Table 12.5.3 Calculation of Core-Mitering Machines Needed for Design Line 8

Trial Standard Level	Multiplier for Increased Core-Mitering Capacity	Number of Core-Mitering Machines if all Transformers are Mitered	Fraction of Transformers that are Mitered	Number of Core-Mitering Machines
TSL1	1.00	2.8	0.30	0.9
TSL2	1.01	2.9	0.95	2.7
TSL3	1.35	3.8	1.00	3.8
TSL4	1.55	4.4	1.00	4.4
TSL5/6	1.78	5.1	1.00	5.1

Based on the assumptions of three full-time equivalent core-mitering machines in the base case and $0.95 M per additional core-mitering machine (including building adder of $0.2 M), the Department estimated that core-mitering equipment capital expenditures for the industry would be $9.5 M, $35.2 M, $67.5 M, $78.9 M, $95.0 M, and $95.0 M for TSL1 through TSL6, respectively. The core-cutting equipment estimates are summarized in Table 12.5.4.

Table 12.5.4 Summary of LV Dry-Type Distribution Transformer Core-Mitering Equipment Capital Expenditures

Trial Standard Level	Mitered Core-Cutting Machines Needed by Industry	Incremental Mitered Core-Cutting Machines Needed by Industry	Core-Mitering Conversion Capital Expenditure (2004$, Millions)
TSL1	13	10	9.5
TSL2	40	37	35.2
TSL3	74	71	67.5
TSL4	86	83	78.9
TSL5/6	103	100	95.0

The number of mitered core-cutting machines required by industry increases with increasing TSL for three reasons. First, as discussed earlier, the Department assumes that at TSL1, 30 percent of the nation's shipments are mitered. At TSL2, this assumption increases to 95 percent, and at TSL3 through TSL6, 100 percent. Thus 70% and 5% of the transformers at TSL1 and TSL2, respectively, are built with butt-lap cores. The Department assumes there is no incremental tooling cost for butt-lap core construction. Second, steel laminations are thinner at higher efficiency, thus for the same core stack height (e.g., 5 inches of steel), a shift from M6 to M3 requires 56 percent more laminations, or 56 percent more pieces of steel that have to be processed and cut. Finally, above TSL2, most of the efficiency improvement is captured by reducing flux density, which involves adding more steel and therefore stack height to the cores. Illustrative of the last two factors, the average number of pieces of core steel in DL7 (75 kVA, 3-phase, LV dry-type) increases from approximately 270 at TSL1 and TSL2, to 485 at TSL3, 560 at TSL4, and 675 at TSL5 and TSL6.

The Department estimates the capital investment for additional miscellaneous equipment, including that needed for coil winding, based on a multiplier applied to the core-cutting equipment capital investment. Industry sources indicated that a multiplier of 1.08 would give a reasonable estimate of the total conversion capital expenditure, including miscellaneous equipment costs such as coil winding machines. For example, during the MIA interviews, manufacturers discussed the costs associated with upgrading their coil winding equipment to enable it to wind copper conductor. Copper requires more torque (i.e., slowing winding speeds) on the winding lathe. The complete conversion capital expenditures for the LV dry-type superclass are summarized in Table 12.5.5.

Table 12.5.5 Summary of LV Dry-Type Distribution Transformer Conversion Capital Expenditures

Trial Standard Level	Core-Cutting Conversion Capital Expenditure (2004$, Millions)	Multiplier for Winding and Miscellaneous Tooling	Total Conversion Capital Expenditure (2004$, Millions)
TSL1	9.5	1.08	10.3
TSL2	35.2		38.0
TSL3	67.5		72.9
TSL4	78.9		85.2
TSL5/6	95.0		102.6

12.5.2 Product Conversion Expenses

Product conversion expenses include engineering, prototyping, testing, marketing, and training expenses incurred by a transformer manufacturer as it prepares for compliance with the standard. The Department based its industry-wide product conversion expense estimates on information submitted by the interviewed manufacturers. It should be noted that contrary to manufacturers of liquid-immersed transformers, manufacturers of LV dry-type do not have flexibility in design. Typically, their customers do not evaluate, therefore the design software, the employees, the equipment, tooling and other infrastructure are not oriented toward custom-build designs. Instead, LV dry-type manufacturers' product lines today are typically concentrated around products at the baseline (lowest first cost) and TSL1 (NEMA TP-1). Product conversion expenses are summarized in Table 12.5.6.

Table 12.5.6 Summary of LV Dry-Type Distribution Transformer Product Conversion Expenses

Trial Standard Level	R&D (2004$, Millions)	Testing (2004$, Millions)	Marketing (2004$, Millions)	UL Listing (2004$, Millions)	Training (2004$, Millions)	TOTAL (2004$, Millions)
TSL1	1.7	1.0	0.4	0	0	3.0
TSL2	6.3	1.2	0.5	0.3	0	8.4
TSL3	6.8	1.5	0.5	0.6	0.3	9.7
TSL4	7.3	1.5	0.5	0.9	0.3	10.6
TSL5	7.7	1.5	0.5	0.9	0.3	10.9
TSL6	7.7	1.5	0.5	0.9	0.3	10.9

The large jump in estimated research and development expenses between TSL1 and TSL2 are attributed to the fact that industry currently produces designs that are compliant with TSL1 but not TSL2. Some research and development would still be required at TSL1 as the entire industry's production would shift to TSL1, but this effort would be focused on optimization and would be much less than the research and development effort required to meet TSL2. Design, prototyping, and testing requirements would be more pronounced at TSL2.

12.5.3 Industry Financial Impacts

Using the inputs and assumptions described in the previous sections, the GRIM estimated the financial impacts on the LV dry-type distribution transformer industry at each TSL. This document reports the output of the GRIM analysis using two key financial metrics: INPV and annual net cash flow to the industry.

12.5.3.1 Trial Standard Levels

The Department developed six TSLs for LV dry-type distribution transformers. TSL1 is the NEMA TP-1 standard. TSL6 represents the maximum TSL that is technologically feasible. TSL5 is the highest TSL that yields national NPV greater than zero. For dry-type transformers, TSL5 and TSL6 are the same. TSL4 results in the maximum LCC savings. TSL2 and TSL3 are spaced equally between TSL1 and TSL4.

12.5.3.2 Impacts on Industry Net Present Value

The INPV measures the industry value and is used in the MIA to compare the industry-wide economic impacts of different TSLs. The INPV is different from the Department's NPV applied to the whole U.S. economy. The INPV is the sum of all net cash flows discounted at the industry's cost of capital or discount rate. The GRIM estimated cash flows between 2004 and 2038, consistent with the forecast period used in the national impact analysis.

In the manufacturer impact analysis, the Department compared the INPV of the base case (no efficiency standard) to that of each TSL. The difference in INPV is an estimate of the economic impacts that implementing each particular TSL would have on the entire industry.

To evaluate the range of cash flow impacts on the industry, the Department constructed two MIA analyses based on the two markup scenarios discussed in section 12.3.7. In the first scenario, the gross margin percentage is held constant at all TSLs (and equal to the base case). In the second scenario, it is assumed that the industry could preserve its operating profit at all TSLs. Tables 12.5.7 and 12.5.8 provide the INPV estimates under the two scenarios.

Table 12.5.7 Changes in LV Dry-Type Industry Net Present Value, Preservation of Gross Margin Percentage Scenario

Trial Standard Level	INPV (2004$, Millions)	Change in INPV from Base Case	
		2004$, Millions	% Change
Base Case	$93	-	-
TSL1	$90	($3.8)	-4.1%
TSL2	$72	($21.1)	-22.6%
TSL3	$53	($40.2)	-43.0%
TSL4	$53	($40.1)	-42.9%
TSL5/6	$57	($36.5)	-39.1%

Table 12.5.8 Changes in LV Dry-Type Industry Net Present Value, Preservation of Operating Profit Scenario

Trial Standard Level	INPV (2004$, Millions)	Change in INPV from Base Case	
		2004$, Millions	% Change
Base Case	$93	-	-
TSL1	$80	($13.8)	-14.7%
TSL2	$56	($37.9)	-40.5%
TSL3	$28	($65.3)	-69.9%
TSL4	$8	($85.9)	-92.0%
*TSL5/6	($22)	($115.8)	-124.0%

* INPV is shown to be negative. Practically, this means that industry value would go to zero. The large impact on INPV would be driven by capital investment, including investments in working capital.

The results from the preservation of gross margin percentage scenario provide a more favorable projection than do the results from the preservation of operating profit scenario. Under a standards scenario, industry is investing heavily during the compliance period to prepare for the effective date of the standard. These investments include both the aforementioned capital equipment and product conversion costs. Industry value would not decrease as much if manufacturers could preserve their gross margin percentage as their production costs increase in response to a standard. However, as previously mentioned, manufacturers felt that the constant gross margin percentage scenario may be optimistic.

The preservation of operating profit scenario provides a lower bound for INPV under a standard. The Department projects that the INPV impact in this scenario will be approximately two to four times as large as that in the preservation of gross margin percentage scenario. This is due to the fact that the same capital equipment investments are being made but the industry is still only making the same operating profit (in absolute dollars) as it did in the base case. The decrease in industry value under both scenarios comes from the inability of industry to fully recoup the capital investments required for standard compliance, including investments in working capital.

12.5.3.3 Impacts on Annual Cash Flow

While INPV is useful for evaluating the long-term effects of standards, short-term changes in net cash flow are also important and indicative of the impacts on industry during the years between final rule publication and the standard effective date. For example, a large investment over a period of a few years could strain the industry's access to capital. Consequently, the sharp drop in net cash flow might lead to additional borrowing; changes in leverage, interest coverage ratios, and/or bond ratings; and possibly increased concern among investors. Thus, a short-term disturbance can have long-term effects that the INPV does not capture. To get an idea of the behavior of annual net cash flows, the Department reports the annual net or free cash flows from 2004 through 2020 for the different TSL levels. Figures 12.5.1 and 12.5.2 present the annual net cash flows for the base case and each of the six TSLs evaluated for the two different markup scenarios.

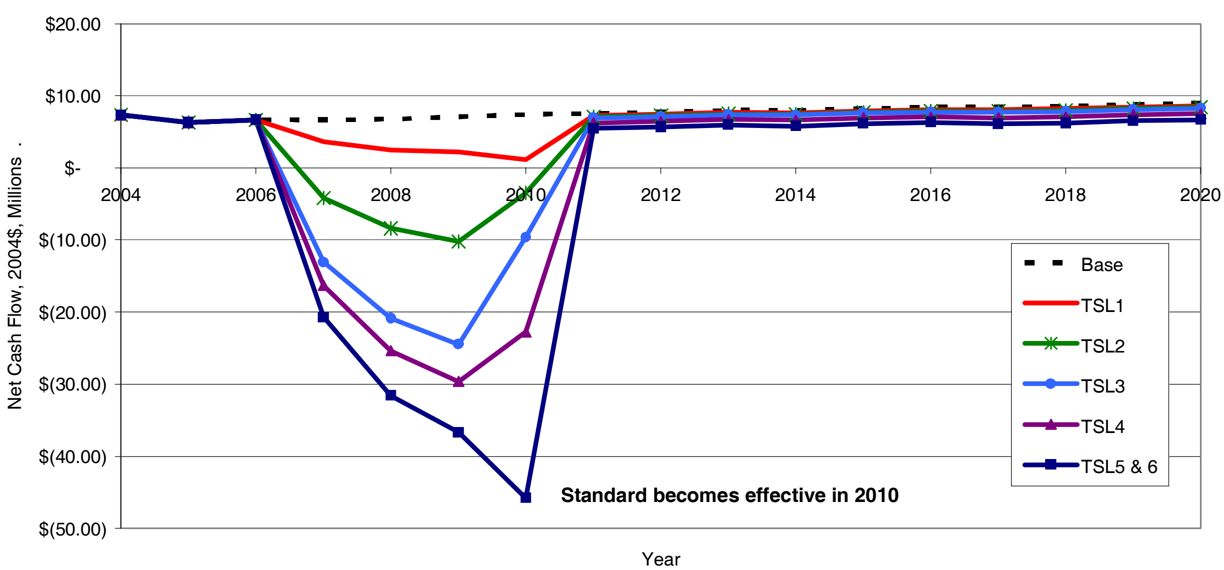

Figure 12.5.1 Industry Net Cash Flow for Preservation of Operating Profit Scenario, LV Dry-type

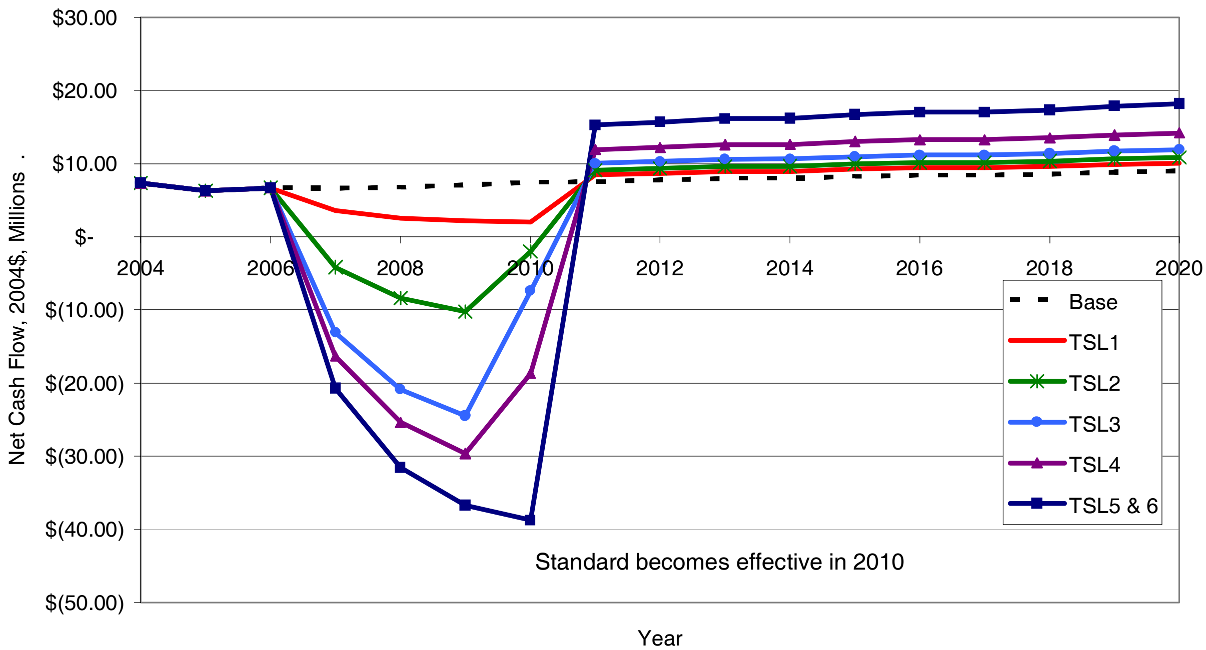

Figure 12.5.2 Industry Net Cash Flow for Preservation of Gross Margin Percentage Scenario, LV Dry-type

Prior to the final rule publication date, the cash flows are identical for all TSLs in both scenarios. After final rule publication, cash flows are driven by the level of capital investments and product conversion expenses and the proportion of these investments spent every year. Additionally, in the year of the standard, a relatively large investment in working capital is required. The incremental investments in working capital are about $6 M, $11 M, $17 M, $30 M, $53 M, and $53 M for TSL1 through TSL6, respectively (with about 5-6 percent variation at each TSL between markup scenarios). After the final rule is published, industry cash flows begin to decline as industry uses its financial resources to prepare for the standard. In the year the standard becomes effective, new capital equipment goes into production. The Department assumed that no assets are stranded for the six TSLs evaluated.

While the behavior of cash flows for each TSL varies between the two markup scenarios, there are two observations that are common across the two scenarios. First, the net annual cash flows go negative for all TSLs except for TSL1. Second, for TSL4 through TSL6, the noticeable impact on cash flow in 2010 is due to a relatively large investment in working capital that would be required to finance increased inventories, accounts receivable, etc.

12.5.4 Other Impacts

12.5.4.1 Employment

Industry-wide labor expenditures are estimated based on the engineering analysis. Winding of the primary and secondary coils, stacking and assembly of the core, enclosure manufacturing, testing, and packing of the completed transformer represent the bulk of the labor. The Department incorporated these assumptions into the GRIM, which projects labor expenditures annually. Labor expenditures are a function of the labor intensity of the product, the sales volume, and an implicit wage assumption that remains fixed over time in real terms. Table 12.5.9 provides the changes in labor measured as the change in labor expenditures for LV dry-type transformers in 2010, the standard effective date, versus the base case.

Table 12.5.9 Projected Change in Labor Expenditures, Low-Voltage Dry-Type (2010)

Trial Standard Level				
TSL1	**TSL2**	**TSL3**	**TSL4**	**TSL5 & 6**
12.4%	5.4%	3.9%	8.1%	13.4%

Based on the GRIM and the assumption that 50 percent of LV dry-type transformers sold in the U.S. are manufactured in the U.S., the Department estimates that there are currently 1,074 production employees in the U.S. LV dry-type distribution transformer industry. Due to the fact that labor content does not vary between the markup scenarios, projected labor expenditures are equivalent for both. Based on these results, DOE expects increased employment levels among transformer manufacturers at all TSLs compared to the base case. The employment level increases at TSL2 and TSL3 are expected to be lower than at other TSLs because of increased use of mitered core construction and improvements in the quality of core steel (i.e., from M6 to M3 and HO). At TSL1 some manufacturers will continue to use buttlap core construction, increasing employment levels. At TSLs 4 through 6, employment level increases will be high due to increasingly larger cores, requiring more labor.

Computationally, the analysis shows that the direct employment impacts will be positive, however the end result could be exactly the opposite. During the MIA interviews, manufacturers stated that at higher standard levels, it becomes increasingly likely that they will relocate their production facilities to Mexico or China, where the labor cost component of a transformer can be reduced. Indeed, in this superclass, more than half of the LV dry-type transformers purchased in the U.S. are imported. Competitive forces have already led to a manufacturing shift to Mexico, as the market seeks to find the lowest cost transformers in the global economy, after accounting for transportation costs (which can be substantial for transformers coming from overseas).

12.5.4.2 Production Capacity

Energy conservation standards will impact the industry's manufacturing capacity because the core stack heights will increase and laminations will become thinner. Thinner laminations require more pieces of steel per inch of core stack, therefore requiring more cuts. Thinner laminations are also more cumbersome to handle. Manufacturers would have to invest in additional core cutting machinery or modifications and improvements to recover any losses in productivity, and these factors might also contribute to a need for more plant floor space.

Because more efficient transformers tend to be larger than standard units, this issue can also contribute directly to the need for additional floor space.

12.5.4.3 Exports

Exports of LV dry-type transformers are not considered to be a significant percentage of domestic shipments. However, during the interviews, manufacturers did not comment that they anticipate the impact of a standard to negatively affect exports.

12.5.4.4 Cumulative Regulatory Burden

While any single regulation may not impose a significant burden on manufacturers, the combined effects of several regulations, existing or pending, may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Assessing the impact of a single regulation may overlook this cumulative regulatory burden.

Companies that produce a wider range of regulated products may be faced with more capital and product development expenditures than their competitors. This can prompt those companies to exit the market or reduce their product offerings, reducing competition. Smaller companies can be especially impacted since they have lower sales volumes over which to amortize the costs of meeting new regulations. The Department considers that a proposed standard is not economically justified if it contributes to an unacceptable level of cumulative regulatory burden.

The Department looked at three areas of regulatory burden: 1) Federal, 2) State, and 3) Other regulations and standards.

1. <u>Federal Regulations on Distribution Transformer Manufacturers</u> - manufacturers were not aware of any federal regulations on low-voltage dry-type distribution transformer manufacturers that would cause a cumulative regulatory burden.

2. <u>Regulations and Pending Regulations at the State Level</u> - manufacturers also discussed the recent trend of state governments to implement NEMA TP-1 as a mandatory standard for transformers sold within state borders. At this time, the Department knows of eight states and one city that require this minimum efficiency standard for LV dry-type distribution transformers. The states requiring TP-1 are California, Connecticut, Maryland, Massachusetts, Minnesota, New York, Oregon, and Wisconsin. The city requiring TP-1 is Burlington, VT. However, these standards, when preempted by federal energy efficiency regulation, will not create a cumulative burden on domestic manufacturers.

3. <u>Other Regulations and Standards</u> - During the MIA interviews, some manufacturers expressed concern regarding Underwriters Laboratories (UL) and other safety agency listing requirements. These requirements could impose a burden on the LV dry-type industry, as transformer manufacturers may need to obtain UL listing for the new standards-compliant transformer designs. The UL listing impact was accounted for in the product conversion expense estimates provided by industry to the Department. Manufacturers were not aware of other regulations or standards, in effect or pending, that affect LV dry-type distribution transformers.

12.5.4.5 Impacts on Small Businesses

The Small Business Administration defines a small business, for the distribution transformer industry, as a business having 750 employees or fewer. The Department estimates that of the approximately 40 U.S. manufacturers that produce LV dry-type distribution transformers, more than 30 of them are small businesses. In such a highly competitive industry, an important manufacturer may ship only a few percent of the market total. Some of the relatively important manufacturers in the industry are small businesses. About two-thirds of the small LV dry-type businesses have fewer than 100 employees.

The LV dry-type distribution transformer market is characterized by off-the-shelf products. In this market, it is difficult for small businesses to be profitable, even in the base case. Small businesses have less leverage over their suppliers and cannot realize the economies of scale enjoyed by larger manufacturers. The competitive position of small LV dry-type manufacturers will likely erode further under an energy conservation standard. At higher TSLs, the competitive position of a small business would be impacted even more.

At TSL3 and higher, the negative net cash flows for the industry during the compliance period are more than twice the magnitude of the positive cash flow in the base case. Thus, the impacts for TSL3 and higher on the LV dry-type industry as a whole are large for businesses of all sizes and overshadow the potential differential impacts on small businesses.

To facilitate discussion of the impacts on small LV dry-type businesses, it is useful to conceptualize these small businesses as coming from the tier two and tier three companies described in the introduction to section 12.5. The impacts on these two tiers will likely be different. Tier two consists of eight or so smaller companies that mass produce catalogue / stock-item LV dry-type transformers. Companies in this tier include Acme Electric (Actuant), Federal Pacific, Jefferson Electric, Sola Hevi-Duty, Hammond, MGM, and Olsun. Tier three companies are smaller, and build some catalogue stock, but tend to be customer-focused, following detailed specifications and producing made-to-order units to sell. The Department's database lists approximately 30 companies that fall into this third tier.

Tier three LV dry-type manufacturers often buy prefabricated cores today. At TSL2, this trend would be reinforced and magnified for two reasons. First, these companies would not have capital budgets large enough to invest in the core mitering equipment that most manufacturers would find necessary to meet TSL2. Second, many of the smallest manufacturers lack the design expertise and labor skills necessary to build cores that would be compliant with TSL2. Not only had many of the smallest manufacturers interviewed by the Department never considered designing above TSL1, many of them were not even aware that a DOE rulemaking for distribution transformers was underway.

The design efforts and reporting requirements alone will likely cause some tier three manufacturers to exit the market, even at TSL1. There seems to be general agreement among manufacturers of all sizes that the smallest, marginal businesses will be at risk after standards implementation, even at TSL1. Similarly, the recent trend for smaller businesses to sell a greater percentage of their products into specialized and niche markets may also be magnified at TSL1 and TSL2. If they possess sufficient engineering expertise, the smallest businesses can still compete effectively in the market for specialized products.

For the tier two LV dry-type manufacturers, the reaction and impacts at TSL1 and TSL2 would likely be more varied. At TSL2, most of these businesses would invest in equipment to cut mitered cores, some would design and construct highly efficient butt-lap constructed cores, and some would purchase pre-cut (mitered) cores. It will be difficult for many small businesses to purchase core-mitering equipment because of the lack of capital typically available to small businesses. Capital outlays for core-mitering equipment may not be justified if other higher return projects exist. This impact will be compounded because of the discrete sizes in which core-mitering equipment is available (i.e., some small businesses would have to buy equipment that is large relative to their production quantities). For those small businesses that opt to construct well-designed butt-lap cores, they will experience a significant variable cost disadvantage at TSL2, but not at TSL1. For this reason, over time, TSL2 would likely have a negative impact either on the market share or the profitability of many small businesses. In addition, as discussed in the Market and Technology Assessment (Chapter 3), the butt-lap designs will be larger, and therefore will disadvantage small manufacturer products from a size and weight perspective, particularly for products that meet TSL2. Small businesses that opt to purchase pre-cut cores will end up sharing a portion of the value-added with their core suppliers, thus eroding the transformer manufacturers' margins. These businesses that opt to purchase pre-cut cores will have to make relatively large investments in working capital to support the increased inventories that will be required for the manufacturer to have the hundreds of cut piece sizes available to be responsive to customer orders for different kVA ratings. This contrasts sharply with the comparatively lower costs of carrying an inventory of a few different width rolls of core steel, which is currently the case. Additionally, the need to procure cores from a third party will erode the flexibility and short delivery times which today enable small manufacturers to compete with lower-cost large manufacturers.

The Department learned about a few other noteworthy impacts on small businesses during the manufacturer interview process. First, irrespective of the standard level, small businesses have lower production over which to spread costs such as design work, testing, prototyping, and UL certification and listing. This would disadvantage small businesses, even at TSL1. Secondly, if a small business decided to exit the ventilated dry-type market because of the costs of complying with the standard, it would impact the small business's profitability in other (non-regulated) product markets by diminishing the volume discounts that manufacturers currently enjoy for certain materials. Finally, small manufacturers perceive themselves at a disadvantage under standards compared to large manufacturers that bundle transformers and switchgear into a single product offering.

12.5.5 Summary of Impacts for Low-Voltage Dry-Type Superclass

The customers for LV dry-type transformers do not generally consider efficiency when purchasing transformers. Price is the prime determinant of customer choice. Most LV dry-type transformers are purchased by contractors or others who do not pay the associated electric bills and therefore do not consider life-cycle costs. TP1-compliant LV dry-type transformer purchases are driven by state mandated efficiency levels and not consumer preferences.

Conversion capital expenditures in the LV dry-type distribution transformer superclass include primarily core-mitering equipment, but some additional expenditures would be necessary to upgrade coil winding equipment and miscellaneous tooling. Today, only a few full-time equivalent core-mitering machines are required by the LV dry-type superclass. At TSL1, the Department estimates that 30 percent of the LV dry-type transformers would be manufactured using core-cutting equipment capable of making mitered cuts. At TSL2, about 95 percent of LV dry-type transformers would require mitered cuts, and at TSL3 and higher, 100 percent of designs would be mitered.

Above TSL1, the core-cutting time per transformer, and consequently the number of core-mitering machines required by the industry, increases because of two factors. First, more core-cutting time is required in proportion to increases in stack height at higher efficiencies. Second, the shift to thinner core steel laminations at higher efficiencies implies increases in core-cutting time that are inversely proportional to lamination thickness. The Department accounted for these two factors in estimating the increases in mitered core-cutting equipment required at each TSL above TSL1. The Department estimated that mitered core-cutting equipment capital expenditures for the industry would be \$10.3 M, \$38.0 M, \$72.9 M, \$85.2 M, \$102.6 M, and \$102.6 M for TSL1 through TSL6, respectively. These are large capital expenditures for a low-margin industry projected to have only \$330 M in revenue in 2007, particularly above TSL2. Other capital conversion expenditures for the LV dry-type superclass would add less than 10 percent to the core-mitering equipment expenditure estimates. Product conversion expenses for the LV dry-type superclass would be signficant above TSL1, based on information submitted by industry. Industry currently makes designs that are compliant with TSL1, so research and development costs would be mitigated at TSL1.

The impact on INPV at TSL5 and TSL6 would range between complete elimination of industry value and -39 percent. The magnitude of the peak negative net cash flow would be about five or six times that of the base case positive net cash flow. The 2010 impacts would largely be driven by the need to invest in working capital. Manufacturers commented that at these levels, with all the shipments based on laser-scribed HO core steel, that global production would be insufficient to meet their needs. Furthermore, at these TSLs, manufacturers stated they would seriously consider either relocating outside the U.S. to recoup some labor costs or simply to exit the business.

At TSL4, the impact on INPV would range between -92 percent and -43 percent. At TSL3, the impact on INPV would range between -70 percent and -43 percent. The impact on annual net cash flow from capital expenditures prior to the standard would be similar for TSL3 and TSL4, but the need to invest in working capital in the standard year would be greater at TSL4. For TSL3 and TSL4, the magnitude of the peak negative net cash flow would be three to four times that of the base case positive net cash flow.

At TSL3 and TSL4, industry would likely see considerable consolidation as not all current manufacturers would invest the capital required to manufacture standards-compliant transformers (and butt-lap designs would not be competitive). Those who remain and do not already have production capability for high efficiency LV dry-type transformers, will consider manufacturing outside the U.S. as it will enable them to capture labor savings on each unit shipped, enhancing their competitiveness and profitability.

At TSL2, the impact on INPV would range between -41 percent and -23 percent. At TSL1, the impact on INPV would range between -15 percent and -4 percent. There would be tangible net cash flow impacts at both TSL1 and TSL2, but the industry as a whole would likely recover in the years following standard implementation. Recovery will be easier at TSL1. Besides the difference in INPV impacts, the primary difference between TSL1 and TSL2 from the manufacturers' viewpoint is that TSL1 preserves more design pathways, each trading off material for capital. Butt-lap designs would be cost-effective at TSL1, which would allow small businesses to remain more competitive because they would not have to make large capital outlays or outsource their core production. TSL2 is a much tougher standard to reach cost-effectively with butt-lap designs, thus TSL2 would hurt the margins or decrease the market share of small businesses in the long-run. However, even at TSL1, some tier three LV dry-type manufacturers (there are approximately 30 of them in the U.S.) would exit the market because of compliance costs, including re-design, testing, and record keeping costs. Many of the smallest manufacturers likely are not aware of the DOE rulemaking and have never contemplated making designs more efficient than TSL1.

12.6 MANUFACTURER IMPACT ANALYSIS - MEDIUM VOLTAGE DRY-TYPE

The MV dry-type transformer market is characterized by large commercial and industrial users, some of which evaluate and are concerned about losses when making transformer purchase decisions. Of the three superclasses, this superclass has the lowest shipments and lowest revenue. In recent years, there has been some consolidation in the MV dry-type industry, with a MV dry-type production facility closing in North Carolina, and the associated business being taken over by a competitor in Virginia.

The Department estimates that there are approximately 25 companies active in the MV dry-type market in the U.S. Of these, the seven largest companies retailing MV dry-type distribution transformers are (in alphabetical order): ABB, Federal Pacific, General Electric, Hammond, MGM, Olsun and Square D. Of the three superclasses, the MV dry-type superclass is the most concentrated - the top three companies manufacture over 75 percent of all transformers in this superclass. For more information on the transformer market in general, and MV dry-type transformers in particular, please see the Market and Technology Assessment (Chapter 3).

12.6.1 Conversion Capital Expenditures

Through its MIA interviews, the Department gained an understanding of the conversion capital expenditures that MV dry-type transformer manufacturers would have to make in response to a standard. These are: 1) investments in additional core-cutting equipment capable of making mitered cuts, and 2) investments in miscellaneous tooling and equipment, including that used for conductor winding. Core-cutting equipment capable of making mitered cuts is a key component of the MV dry-type analysis. Mitered and cruciform core construction techniques are often used to reduce no-load losses in MV dry-type transformers. Mitered joints have lower destruction factors and are more efficient than butt-lap joints.

Reviewing the shipments analysis, the Department estimated that the equivalent of five full-time mitered core-cutting machines are currently being used by the MV dry-type industry. The Department estimates that about 85 percent of the MV dry-type transformers produced today have mitered cores. At TSL1, the Department assumed that 95 percent of the MV dry-type transformers would be manufactured using mitered cores. At TSL2 and above, the Department assumed that 100 percent of the MV dry-type transformers would be manufactured using core-cutting equipment capable of making mitered cuts.

The Department provided a few core designs from the MV dry-type engineering database to the primary supplier of core-cutting equipment. This equipment manufacturer then prepared processing time estimates based on the core dimensions. The manufacturer's assumptions are applicable for processing M6 core steel in batches of one. The assumption of single unit batches is appropriate for the MV dry-type superclass because there is often a high degree of customization associated with customer orders. Based on the core-cutting equipment manufacturer's processing time estimates, the Department derived the following production assumptions - for design lines 9 through 13, the number of cores produced per machine per year are estimated to be 1,400; 700; 1,400; 700; and 525, respectively. A representative core-mitering machine is projected to cost the MV dry-type distribution transformer industry about $2.4 M installed, plus $0.3 M for expanded building capacity. Because of the large amount of core steel that needs to be processed for a typical MV dry-type transformer, and the increased cutting requirements at higher efficiency due to greater stack height (or piece length) and thinner laminations, industry indicated that additional core stacking equipment would be necessary to optimize production at higher TSLs. The Department recognizes the potential for this automatic core stacking machine expenditure and accounted for it by assuming that the core-mitering equipment purchased by the MV dry-type industry would include automatic core-stacking capability. Core-mitering equipment in the MV dry-type industry typically includes such core-stacking capability.

At TSL1 and higher, the processing time per core is higher than for the base case, increasing the number of mitered-core cutting machines required by the superclass. The processing time per core increases for two reasons: 1) more core-cutting time is required as core size increases with higher efficiencies, and 2) the processing time increases in inverse proportion to lamination thickness and more efficient grades of steel typically are thinner (e.g., lamination thickness changes from 0.011" for M4 to 0.009" for M3, representing a 22 percent increase in core-mitering time for M3). Some manufacturers report that their core-mitering equipment operates poorly with thinner steels, which would require them to operate at lower speeds, exacerbating the capacity impacts. Estimates of the core size increases and lamination thickness changes are based on the engineering analysis. The Department accounted for these two factors in estimating the increases in core-mitering equipment required at each TSL. Table 12.6.1 shows an example calculation for the core-mitering capacity multiplier at each TSL for DL9, not accounting for the fraction of transformers that are mitered at each TSL.

Table 12.6.1 Calculation of Core-Mitering Capacity Multiplier for Design Line 9

Trial Standard Level	Typical Core Weight (lbs)	Typical Stack Height (in.)	Typical Lamination Thickness (in.)	Typical Number of Laminations per Inch (in^{-1})	*Multiplier for Increased Core-Mitering Capacity
Base Case	1,251	6.94	0.0114	87.4	1.00
TSL1	1,221	6.89	0.0109	91.5	1.04
TSL2	1,230	7.06	0.0092	109	1.26
TSL3	1,235	7.80	0.0090	111	1.43
TSL4	1,238	8.19	0.0090	111	1.50
TSL5/6	1,588	10.20	0.0090	111	1.93

* For TSL1 - TSL4, the multiplier is based on the ratios of stack heights and number of laminations per inch, normalized to the base case. For example, at TSL3, the multiplier is calculated as (7.80/6.94)×(111/87.4) = 1.43.

For TSL5 and TSL6, the multiplier is based on the ratios of core weight and number of laminations per inch, normalized to TSL4. At TSL5 and TSL6, the multiplier is calculated as (1,588/1,238)×(111/111)×1.50 = 1.93. The multiplier at TSL5 and TSL6 is calculated differently because for some MV dry-type design lines, particularly DL12 which is high volume and therefore critical for the analysis, the designs in the engineering database involve longer pieces of core steel above TSL4 and therefore the required increased cutting time is better captured through core weight increases than through stack height increases (in the Department's engineering analysis stack height increases are not significant for DL12 above TSL4). The Department confirmed the assumption that core steel piece length (and consequently weight when stack height and piece width are relatively fixed) is an important determinant of mitering time after speaking with the primary supplier of core-mitering equipment and reviewing equipment performance curves.

Base case 2010 unit shipments projections for DL9 through DL13 are 372; 592; 423; 2,761; and 260, respectively. Using these shipments projections, the assumed core production rates per core-mitering machine for each design line (discussed above), and the multipliers for increased core-mitering capacity, the Department estimated the number of core-mitering machines needed at each TSL. Table 12.6.2 through Table 12.6.6 provide the calculations for the estimated number of core-mitering machines needed at each TSL for DL9 through DL13, respectively.

Table 12.6.2 Calculation of Core-Mitering Machines Needed for Design Line 9

Trial Standard Level	**Multiplier for Increased Core-Mitering Capacity**	**Number of Core-Mitering Machines if all Transformers are Mitered**	**Fraction of Transformers that are Mitered**	**Number of Core-Mitering Machines**
Base Case	1.00	*0.27	0.85	0.23
TSL1	1.04	0.28	0.95	0.26
TSL2	1.26	0.34	1.0	0.34
TSL3	1.43	0.38	1.0	0.38
TSL4	1.50	0.40	1.0	0.40
TSL5/6	1.93	0.51	1.0	0.51

* (372 units shipped)/(1,400 units per machine per year) = 0.27 core mitering machines

Table 12.6.3 Calculation of Core-Mitering Machines Needed for Design Line 10

Trial Standard Level	**Multiplier for Increased Core-Mitering Capacity**	**Number of Core-Mitering Machines if all Transformers are Mitered**	**Fraction of Transformers that are Mitered**	**Number of Core-Mitering Machines**
Base Case	1.00	*0.85	0.85	0.72
TSL1	1.09	0.92	0.95	0.87
TSL2	1.11	0.94	1.0	0.94
TSL3	1.21	1.02	1.0	1.02
TSL4	1.23	1.04	1.0	1.04
TSL5/6	1.71	1.44	1.0	1.44

* (592 units shipped)/(700 units per machine per year) = 0.85 core mitering machines

Table 12.6.4 Calculation of Core-Mitering Machines Needed for Design Line 11

Trial Standard Level	Multiplier for Increased Core-Mitering Capacity	Number of Core-Mitering Machines if all Transformers are Mitered	Fraction of Transformers that are Mitered	Number of Core-Mitering Machines
Base Case	1.00	*0.30	0.85	0.26
TSL1	1.28	0.39	0.95	0.37
TSL2	1.31	0.40	1.0	0.40
TSL3	1.38	0.42	1.0	0.42
TSL4	1.32	0.40	1.0	0.40
TSL5/6	1.54	0.46	1.0	0.46

* (423 units shipped)/(1,400 units per machine per year) = 0.30 core mitering machines

Table 12.6.5 Calculation of Core-Mitering Machines Needed for Design Line 12

Trial Standard Level	Multiplier for Increased Core-Mitering Capacity	Number of Core-Mitering Machines if all Transformers are Mitered	Fraction of Transformers that are Mitered	Number of Core-Mitering Machines
Base Case	1.00	*3.94	0.85	3.35
TSL1	1.10	4.35	0.95	4.13
TSL2	1.22	4.81	1.0	4.81
TSL3	1.30	5.14	1.0	5.14
TSL4	1.32	5.19	1.0	5.19
TSL5/6	1.76	6.96	1.0	6.96

* (2,761 units shipped)/(700 units per machine per year) = 3.94 core mitering machines

Table 12.6.6 Calculation of Core-Mitering Machines Needed for Design Line 13

Trial Standard Level	Multiplier for Increased Core-Mitering Capacity	Number of Core-Mitering Machines if all Transformers are Mitered	Fraction of Transformers that are Mitered	Number of Core-Mitering Machines
Base Case	1.00	*0.50	0.85	0.42
TSL1	1.01	0.50	0.95	0.47
TSL2	1.11	0.55	1.0	0.55
TSL3	1.17	0.58	1.0	0.58
TSL4	1.17	0.58	1.0	0.58
TSL5/6	1.67	0.83	1.0	0.83

* (260 units shipped)/(525 units per machine per year) = 0.50 core mitering machines

Based on the assumption that each core-mitering machine for the MV dry-type industry would cost $2.7 M installed (including $0.3 M for the building adder), the Department estimated that core-mitering equipment capital expenditures for the industry would be $3.1 M, $5.6 M, $6.9 M, $7.1 M, $14.1 M and $14.1 M for TSL1 through TSL6, respectively. The core-cutting equipment estimates are summarized in Table 12.6.7.

Table 12.6.7 Summary of MV Dry-Type Distribution Transformer Core-Cutting Equipment Capital Expenditures

Trial Standard Level	Mitered Core-Cutting Machines Needed by Industry	Incremental Mitered Core-Cutting Machines Needed by Industry	Core-Mitering Conversion Capital Expenditure (2004$, Millions)
Base Case	5.0	-	-
TSL1	6.1	1.1	3.1
TSL2	7.0	2.0	5.6
TSL3	7.5	2.5	6.9
TSL4	7.6	2.6	7.1
TSL5/6	10.2	5.2	14.1

The Department estimated total conversion capital expenditures, including capital investments for additional miscellaneous equipment such as coil winding equipment, based on multipliers applied to the core-cutting equipment capital investment. Based on information submitted to the Department by industry, this multiplier was estimated to be 1.06. The conversion capital expenditures are summarized in Table 12.6.8.

Table 12.6.8 Summary of MV Dry-Type Distribution Transformer Conversion Capital Expenditures

Trial Standard Level	Core-Cutting Conversion Capital Expenditure (2004$, Millions)	Multiplier for Miscellaneous Tooling Including Coil Winding Equipment	Total Conversion Capital Expenditure (2004$, Millions)
TSL1	3.1	1.06	3.2
TSL2	5.6		5.9
TSL3	6.9		7.3
TSL4	7.1		7.5
TSL5/6	14.1		15.0

12.6.2 Product Conversion Expenses

Product conversion expenses include engineering, prototyping, testing, and marketing expenses incurred by a manufacturer as it prepares to come into compliance with a standard. The Department assumes that product conversion expenses for MV dry-type transformer manufacturers at TSLs 3 through 6 will require total additional expenses equivalent to 100 percent of the industry's R&D budget for 3 years. At TSL3 and above, manufacturers indicated that research and development engineers would be fully utilized (both electrical and mechanical engineers), along with production design engineers and mechanical drafters during the conversion and compliance period. Since manufacturers already produce relatively large volumes of transformers that would comply with TSL1 and TSL2, product conversion expenses are expected to be negligible for these lower TSLs. Product conversion expenses are summarized in Table 12.6.9.

Table 12.6.9 Summary of MV Dry-Type Distribution Transformer Product Conversion Expenses

Trial Standard Level	**Basis**	**Product Conversion Expenses (2004$, Millions)**
TSL1 - TSL2	Industry makes relatively large volumes of these transformers today.	0
TSL3	Amount equal to 100% of industry R&D budget for 3 years.	3.3
TSL4	Amount equal to 100% of industry R&D budget for 3 years.	3.6
TSL5/6	Amount equal to 100% of industry R&D budget for 3 years.	5.0

12.6.3 Industry Financial Impacts

Using the inputs and assumptions described in the previous sections, the GRIM produced indicators of financial impacts on the MV dry-type distribution transformer industry at each TSL. This document reports the results of the MIA using two key financial metrics: INPV and annual net cash flow to the industry.

12.6.3.1 Trial Standard Levels

The Department developed six TSLs for MV dry-type distribution transformers. TSL1 is the NEMA TP-1 standard. TSL6 represents the maximum TSL that is technologically feasible. TSL5 is the highest TSL that yields national NPV greater than zero. For dry-type transformers, TSL5 and TSL6 are the same. TSL4 results in the maximum LCC savings. TSL2 and TSL3 are spaced equally between TSL1 and TSL4.

12.6.3.2 Impacts on Industry Net Present Value

The INPV measures the industry value and is used in the MIA to compare the industry-wide economic impacts of different TSLs. The INPV is different from the Department's NPV applied to the whole U.S. economy. The INPV is the sum of all net cash flows discounted at the industry's cost of capital or discount rate. The GRIM estimated cash flows between 2004 and 2038, consistent with the forecast period used in the national impact analysis.

In the manufacturer impact analysis, the Department compared the INPV of the base case (no efficiency standard) to that of each TSL. The difference in INPV is an estimate of the economic impacts that implementing each particular TSL would have on the entire industry.

To evaluate the range of cash flow impacts on the industry, the Department constructed two MIA analyses based on the two markup scenarios discussed above. In the first scenario, the gross margin percentage is held constant at all TSLs (and equal to the base case). In the second scenario, it is assumed that the industry could preserve its operating profit at all TSLs. Tables 12.6.10 and 12.6.11 provide the net present value estimates for the industry under the two scenarios.

Table 12.6.10 Changes in MV Dry-Type Industry Net Present Value, Preservation of Gross Margin Percentage Scenario

Trial Standard Level	INPV (2004$, Millions)	Change in INPV from Base Case	
		2004$, Millions	% Change
Base Case	$32	-	-
TSL1	$30	($1.8)	-5.5%
TSL2	$29	($3.3)	-10.1%
TSL3	$27	($5.1)	-15.7%
TSL4	$28	($3.8)	-11.8%
TSL5/6	$30	($2.0)	-6.1%

Table 12.6.11 Changes in MV Dry-Type Industry Net Present Value, Preservation of Operating Profit Scenario

Trial Standard Level	INPV (2004$, Millions)	Change in INPV from Base Case	
		2004$, Millions	% Change
Base Case	$32	-	-
TSL1	$30	($2.5)	-7.7%
TSL2	$28	($4.3)	-13.4%
TSL3	$25	($6.9)	-21.5%
TSL4	$24	($7.8)	-24.3%
TSL5/6	$15	($17.0)	-52.8%

The results from the preservation of gross margin percentage scenario provide a more favorable projection than do the results from the preservation of operating profit scenario. Industry value would not decrease as much if manufacturers could sustain a constant gross margin percentage as their production costs increase in response to a standard. However, as previously mentioned, the preservation of gross margin percentage assumption may be optimistic. It noted that, in the preservation of gross margin percentage scenario, impacts above TSL3 decline with increasing TSL. This is because the incremental conversion costs above TSL3 are small relative to the revenue gains under the preservation of gross margin percentage scenario. The preservation of operating profit scenario provides a lower bound for INPV under a standard. The decrease in industry value under both scenarios comes from the inability of industry to fully recoup the capital investments required for standard compliance, including investments in working capital.

12.6.3.3 Impacts on Annual Cash Flow

While INPV is useful for evaluating the long-term effects of standards, short-term changes in net cash flow are also important and indicative of the impacts on industry during the years between final rule publication and the standard effective date. For example, a large investment over a period of a few years could strain the industry's access to capital. Consequently, the sharp drop in net cash flow might lead to additional borrowing; changes in leverage, interest coverage ratios, and/or bond ratings; and possibly increased concern among investors. Thus, a short-term disturbance can have long-term effects that the INPV cannot capture. To get an idea of the behavior of annual net cash flows, the Department reports the annual net or free cash flows from 2004 through 2020 for the different TSL levels. Figures 12.6.1 and 12.6.2 present the annual net cash flows for the base case and each of the six TSLs evaluated for the two different markup scenarios.

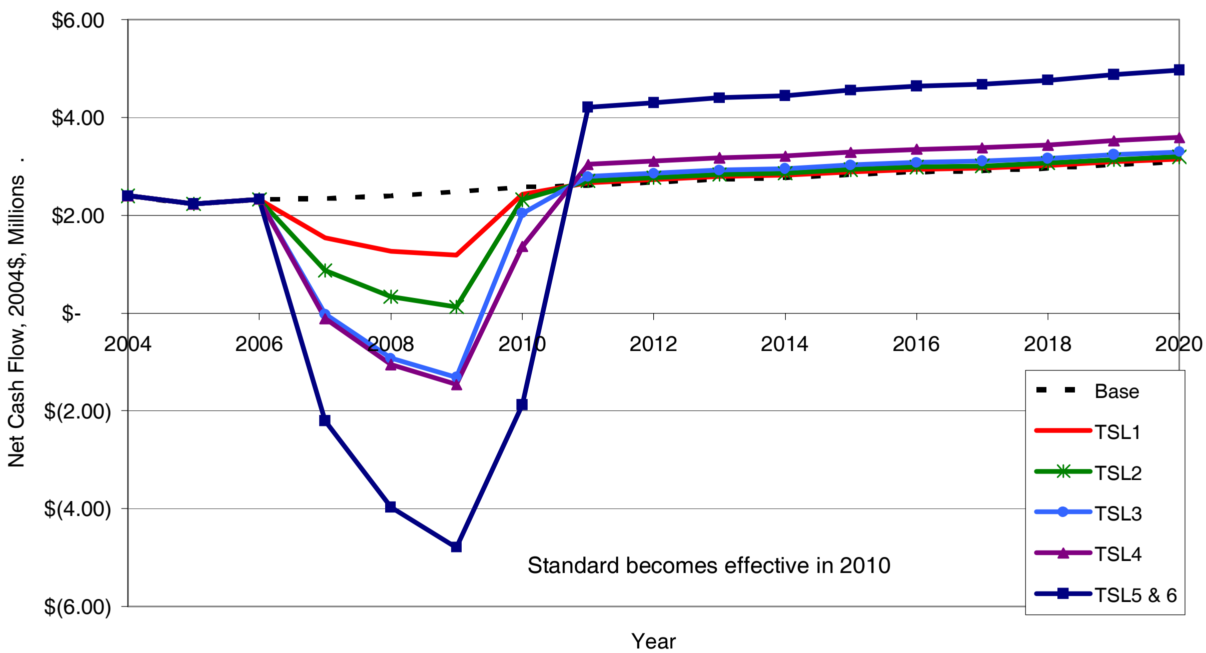

Figure 12.6.1 Industry Net Cash Flow for Preservation of Gross Margin Percentage Scenario, MV Dry-type

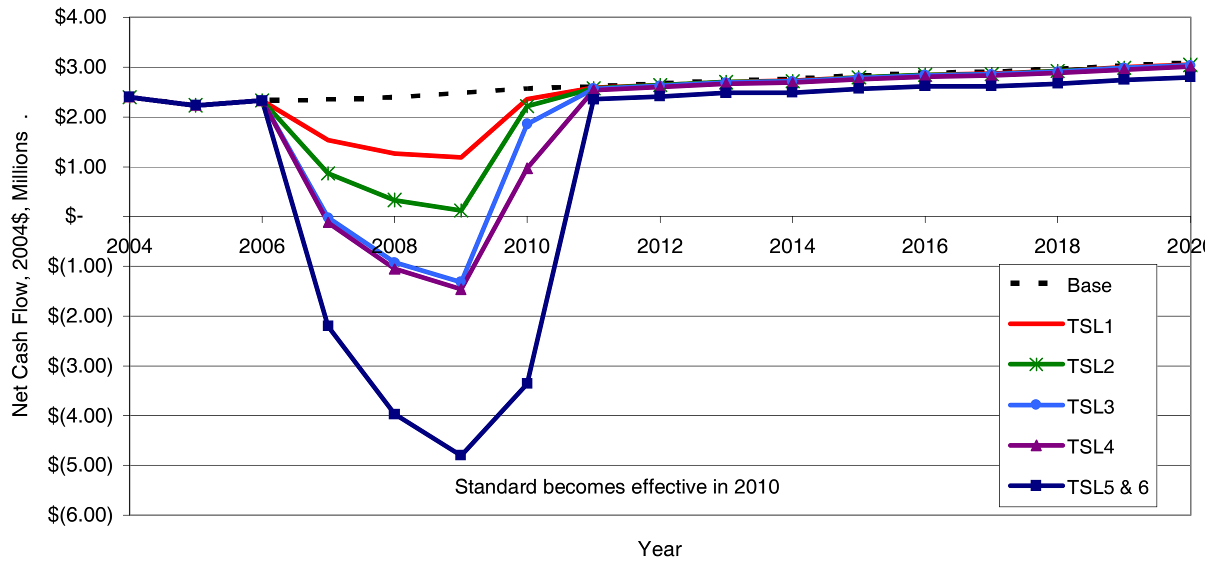

Figure 12.6.2 Industry Net Cash Flow for Preservation of Operating Profit Scenario, MV Dry-type

Prior to the final rule publication date, the cash flows are identical for all TSLs in both scenarios. After final rule publication, cash flows are driven by the level of capital investments and the proportion of these investments spent every year. In addition, in the year of the standard, investment in working capital is required. The incremental investments in working capital are about $0.20 M, $0.34 M, $0.66 M, $1.56 M, $5.90 M, and $5.90 M for TSL1 through TSL6, respectively (with about 5-6 percent variation at each TSL between markup scenarios). These investments in working capital are relatively insignificant, except those at TSL5 and TSL6. After final rule publication, industry cash flows begin to decline as industry uses its financial resources to prepare for the standard. In the year the standard becomes effective, new capital equipment goes into production. It is assumed that no assets are stranded for the TSLs evaluated.

While the behavior of cash flows for each TSL varies between the two markup scenarios, there are two observations that are common across the two scenarios. First, the net annual cash flows go negative at TSL3 and above. Second, net annual cash flows go nearly to zero during the compliance period at TSL2 but not at TSL1.

12.6.4 Other Impacts

12.6.4.1 Employment

Industry-wide labor expenditures are estimated based on the engineering analysis. Winding of the primary and secondary coils, stacking and assembly of the core, enclosure manufacturing, testing, and packing of the completed transformer represent the bulk of the labor. The Department incorporated these assumptions into the GRIM, which projects labor expenditures annually. Labor expenditures are a function of the labor intensity of the product, the sales volume, and an implicit wage assumption that remains fixed over time. Table 12.6.12

provides the changes in labor measured as the change in labor expenditures for MV dry-type transformers in 2010, the standard effective date, versus the base case.

Table 12.6.12 Projected Change in Labor Expenditures, Medium-Voltage Dry-Type (2010)

Trial Standard Level				
TSL1	**TSL2**	**TSL3**	**TSL4**	**TSL5 & 6**
2.1%	-1.0%	-1.4%	-1.6%	-0.1%

Based on the GRIM and the assumption that 100 percent of MV dry-type transformers sold in the U.S. are manufactured in the U.S., the Department estimates that there are currently 252 production employees in the U.S. MV dry-type distribution transformer industry. The Department recognizes that this estimate is somewhat low, perhaps by 30 percent. This estimate excludes non-production workers and assumes a level annual production rate. In practice, including non-production workers and seasonal effects, the actual number of employees in the MV dry-type superclass would be higher. Because labor content does not vary between the markup scenarios, projected labor expenditures are equivalent for both. Based on these results, DOE expects no significant discernable employment impacts among MV dry-type transformer manufacturers for any TSL compared to the base case. Increased employment levels are not expected at higher TSLs because the Department assumed that the core-cutting equipment typically purchased by the MV dry-type industry is highly automated and includes core-stacking equipment. This conclusion is independent of any conclusions regarding employment impacts from the broader U.S. economy.

Another concern relayed by some manufacturers during the interviews is the potential impact stemming from the cast-coil transformer exemption. These manufacturers claim that setting a standard above a certain threshold may trigger a market switch from standards-compliant, open-wound transformers to exempt cast-coil transformers. If the market does shift to cast-coil, there is a risk of imported pre-fabricated cast-coils dominating the market in the long-term. This would have a significant effect on domestic industry value and domestic employment.

Some manufacturers feel that regulation at any level will decrease the diversity of transformer designs which will make it easier for foreign production to compete in the U.S. market. These manufacturers claim that designs may cluster around the standard, allowing foreign competition to produce large quantities of common kVA rated transformers at lower labor costs.

12.6.4.2 Production Capacity

Energy conservation standards will impact the industry's manufacturing capacity because the core stack heights (or core steel piece length) will increase and laminations will become thinner. Thinner laminations require more cuts and are more cumbersome to handle. Therefore, manufacturers would have to invest in additional core-mitering machinery or modifications and improvements to recover any losses in productivity, and these factors might also contribute to a need for more plant floor space. Because more efficient transformers tend to be larger, this could also contribute to the need for additional floor space.

12.6.4.3 Exports

Distribution transformer exports comprise a small fraction of distribution transformer sales. However, domestic manufacturers do sell to nations that do not currently require products to meet minimum efficiency requirements for distribution transformers. Since the MV dry-type industry is largely a customized industry, the impact of a standard on U.S. exports will be minimal.

12.6.4.4 Cumulative Regulatory Burden

While any single regulation may not impose a significant burden on manufacturers, the combined effects of several regulations, existing or pending, may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Assessing the impact of a single regulation may overlook this cumulative regulatory burden.

Companies that produce a wider range of regulated products may be faced with more capital and product development expenditures than their competitors. This can prompt those companies to exit the market or reduce their product offerings, potentially reducing competition. Smaller companies can be especially impacted since they have lower sales volumes over which to amortize the costs of meeting new regulations. The Department considers that a proposed standard is not economically justified if it contributes to an unacceptable level of cumulative regulatory burden.

The Department looked at three areas of regulatory burden: 1) Federal, 2) State, and 3) Other regulations and standards.

1. <u>Federal Regulations on Distribution Transformer Manufacturers</u> - manufacturers were not aware of any federal regulations on medium-voltage dry-type distribution transformer manufacturers that would cause a cumulative regulatory burden in conjunction with the efficiency regulations on distribution transformers.

2. <u>Regulations and Pending Regulations at the State Level</u> - manufacturers discussed the recent trend of state governments in instituting NEMA TP-1 as a mandatory standard for transformers sold within their state's borders. At this time, three states and one city require this minimum efficiency standard for MV dry-type distribution transformers. The states requiring TP-1 are Massachusetts, Minnesota, and Oregon. The city requiring TP-1 is Burlington, VT. Federal regulation would preempt these standards so no cumulative burden would be imposed.

3. <u>Other Regulations and Standards</u> - manufacturers were not aware of other regulations or standards, in effect or pending, that pertain to MV dry-type distribution transformers.

12.6.4.5 Impacts on Small Businesses

The Small Business Administration defines a small business, for the distribution transformer industry, as a business that has 750 employees or fewer. The Department estimates that of the 25 U.S. manufacturers that make MV dry-type distribution transformers, about 20 of them are small businesses. About one-half of the small businesses have fewer than 100 employees.

At TSL3 and above, net cash flows for the MV dry-type industry will go negative during the compliance period. At TSL3 and above, the impacts on the industry as a whole are large and affect businesses of all sizes, but there would be some differential impacts on small businesses. At TSL3 and above, it is noted that the use of M3 core steel will be needed. Cutting M3 core steel on the core-mitering equipment typically purchased by smaller businesses can be problematic because of the extremely thin laminations. Small businesses would also be at a relative disadvantage at TSL3 and higher because research and development efforts would be on the same scale as those for larger companies, but these expenses would be recouped over lower sales volumes by small businesses. Product redesign costs tend to be fixed and do not scale with sales volume.

At TSL2, all designs would have to be mitered. This could constrain the core-mitering resources of small businesses that share core-cutting capacity between LV dry-type and MV dry-type transformers. At TSL1, many kVA ratings could still be constructed using butt-lap joints, alleviating the constraint on core-mitering resources. Thus, TSL1 is less capital-intensive for small businesses than TSL2. In an industry such as MV dry-type, which is heavily consolidated already, there is the risk that TSL2 could lead to further advantage for the largest manufacturers and thus further concentrate the industry's production.

12.6.5 Summary of Impacts for Medium-Voltage Dry-Type Superclass

More than one-half of the customers for MV dry-type transformers consider efficiency when purchasing transformers. A sizeable portion of the market is evaluating losses and making rational economic judgements in purchasing transformer products. With this in mind, it is significant to note that about one percent or less of the market chooses to purchase transformers that meet TSL3 or above.

Conversion capital expenditures in the MV dry-type distribution transformer superclass include primarily core-mitering equipment, but some additional expenditures would be necessary to upgrade coil winding equipment and miscellaneous tooling. Today, about five full-time equivalent core-mitering machines are required by the MV dry-type superclass. At TSL1, the Department estimates that 95 percent of the MV dry-type transformers would be manufactured using core-cutting equipment capable of making mitered cuts. At TSL2 and above, 100 percent of MV dry-type transformers would be produced with core-mitering equipment.

The core-cutting time per transformer, and consequently the number of core-mitering machines required by the industry, increases with increasing TSL because of two factors. First, more core-cutting time is required in proportion to increases in core size at higher efficiencies. Second, the shift to thinner core steel laminations at higher efficiencies implies increases in core-cutting time that are inversely proportional to lamination thickness. The Department accounted for these two factors in estimating the increases in core-cutting equipment required at each TSL. The Department estimated that total equipment capital expenditures for the industry would be $3.2 M, $5.9 M, $7.4 M, $7.5 M, $15.0 M, and $15.0 M for TSL1 through TSL6, respectively. Product conversion expenses for the MV dry-type superclass would be negligible at TSL1 and TSL2 because products meeting these levels are produced in relatively large volumes today. Above TSL2, product conversion expenses would become more significant.

The impact on INPV at TSL5 and TSL6 would range between -53 percent and -6 percent. The impact on INPV at TSL4 would range between -24 percent and -12 percent. The impact on INPV at TSL3 would range between -22 percent and -16 percent. In the preservation of gross margin percent scenario, impacts above TSL3 decline with increasing TSL. This is because the incremental conversion costs above TSL3 are small relative to the revenue gains under the preservation of gross margin percent scenario. This counterintuitive trend does not exist for the low markup scenario, the preservation of operating profit scenario. Net annual cash flows would go negative during the compliance period, irrespective of the markup scenario, for TSLs 3 through 6. For TSLs 3 and 4, the magnitude of the peak negative net annual cash flow would be about half of that of the positive base case cash flow. For TSLs 5 and 6, the magnitude of the peak negative net annual cash flow would be more than twice that of the positive base case cash flow.

For some of the MV dry-type design lines, the cost-effective designs at TSL4 would require laser-scribed domain refined, HO core steel. In the U.S., this steel is only manufactured by one company. HO is also manufactured in Japan, but steel imports from Japan are subject to import duties, providing a production cost advantage to foreign transformer manufacturers. The cost-effective designs at TSL3 would likely rely on M3 core steel and copper windings. TSL3 would therefore not have the same supply chain constraints as TSL4.

At TSL2, the impact on INPV would range between -13 percent and -10 percent. At TSL1, the impact on INPV would range between -8 percent and -6 percent. The impact on annual net cash flow from capital expenditures during the compliance period would be greater for TSL2 than for TSL1. At TSL2, the net annual cash flows would go nearly to zero during the compliance period. The primary difference between TSL1 and TSL2 from the manufacturers' viewpoint is that TSL1 preserves more design pathways, each trading off material for capital. Butt-lap designs would be cost-effective at TSL1 for some kVA ratings, which would allow small businesses to remain more competitive because they would not necessarily have to make large capital outlays. TSL2 cannot be met cost-effectively with butt-lap designs, thus TSL2 would hurt the margins or decrease the market share of small businesses in the long-run.

Finally, there are three additional factors to be considered from the standpoint of manufacturers in selecting the proposed standard:

1. If the MV dry-type standard is set low relative to that for liquid-immersed transformers, there could be a switch to MV dry-type transformers for certain products where there is substitutability between the two superclasses. For otherwise equivalent transformers, the TSLs are less stringent for MV dry-type transformers.

2. Cast-coil transformers are currently exempt from NEMA TP-1, and the Department may exempt them from the standard. Pushing the MV dry-type standard too high could trigger a market switch from standards-compliant open-wound to exempt cast-coil designs. If the market does shift to cast-coil, there is a risk of prefabricated Chinese imported cast-coils dominating the market in the long-term.

3. The MV dry-type superclass is already heavily consolidated. If the standard is set above TSL1, it will likely increase consolidation because the largest manufacturers are better equipped to produce transformers at TSL2 or TSL3.

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